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OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL 35 FEBRUARY 1913 NUMBER 2

MEETING IN GERMANY, 1913

Our hosts, the Verein deutscher Ingenieure, have advised us that since the meeting in Leipzig will occur during the summer vacation season, when the hotel accommodations will be strained to the utmost, and also in view of the difficulties of conducting large groups through industrial establishments, our official party must be limited to two hundred members and one hundred ladies. Notwithstanding this limitation, it has been the experience of the Society on similar occasions that all who actually go will in all probability be included in the official party.

The Committee on Arrangements have been able to secure from the Hamburg-American Line a discount of 5 per cent from the regular tariff on bookings made for the official S.S. Victoria Luise, where such discount will not bring the net price below the fixed minimum, and for the return passage a discount of 20 per cent from the regular tariff to those who return by this line previous to August 1, 1913, provided that the net price does not fall below the fixed minimum rates. At the present time the Hamburg-American Line estimate that the total cost of the official land trip through Germany, commencing at Hamburg, June 21, and concluding at Munich, July 7, will be approximately $80 per person. The Committee on Arrangements have not agreed on a definite figure as yet and are now awaiting a further proposal from the company.

The estimated possible minimum cost of the entire trip is as follows:

Outgoing voyage on S.S. Victoria Luise	$97.50 Minimum
Official Trip through Germany to Munich, approx	80.00
Second Class ticket from Munich to Hamburg	10.90
Return voyage on Hamburg-American Line, estimated	100.00
	$288.40

The reductions will hold under conditions stated above for return trip on the following steamers of the Hamburg-American Line:

To New York:

Kaiserin Auguste Victoria, sailing Thursday, July 17, Min. Rate $115.00

Imperator, sailing Wednesday, July 30, Min. Rate 130.00

To Boston:

Cleveland, sailing Thursday, July 10, Min. Rate 97.50

Cincinnati, sailing Tuesday, July 29, Min. Rate 97.50

All reservations should be made direct with the Hamburg-American Line. Branch offices are located in the following cities: San Francisco, Boston, Philadelphia, Chicago, St. Louis and Pittsburgh. No other than the principal and the above branch offices may take reservations as this is a special steamer at special rates for our party. Those of the party who take outgoing passage on the Victoria Luise assume no obligation in connection with their return passage, but owing to the common desire of most American travelers to return at approximately the same time it is advisable that all secure their return voyage accomodations on some line at the time of making bookings for the outgoing trip.

Attention is drawn to the fact that although we are obliged at present to limit the number of the party which may participate in the official events in Germany, any number of members and friends may accompany the party on the trip over. The Victoria Luise will accommodate about 450 cabin passengers, and it is strongly urged that the entire vessel be occupied by the Society and its friends. The Committee consider as members of the official party to date only those who have either advised the Committee that they will join the official party in Europe or who have actually taken accommodations on the official steamer. Applications will be registered in the order of their receipt at

the headquarters of the Society. When the prescribed limit has been reached, any vacancies which may occur in the party will be filled in the order of the receipt of requests.

Under these circumstances, the Committee on Arrangements, E. D. Meier, Chairman, have been obliged to urge the members to make a definite statement of their intention to join the party, not later than February 1, 1913.

OFFICERS BOOKED TO SAIL ON THE VICTORIA LUISE OR INTENDING TO JOIN THE PARTY

Past-Presidents

John E. Sweet	S. T. Wellman	Jesse M. Smith
Robert W. Hunt	Ambrose Swasey	E. D. Meier
Worcester R. Warner	John R. Freeman	James M. Dodge

Vice-Presidents

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C. J. Davidson
Stanley G. Flagg, Jr.
Henry Hess
George A. Orrok

Treasurer
William H. Wiley

Secretary
Calvin W. Rice

MEMBERS WHO WILL JOIN THE OFFICIAL PARTY IN EUROPE

M. W. Alexander
R. W. Boenig
H. H. Braum
F. J. Cole
M. Estabrook
Peter Eyermann
E. A. Garratt
Carl A. Hall
Douglas T. Heap
N. Baashuus Jessen
Wm. Lyall
Lewis F. Morgan
William F. Morgan
G. A. Pennock
A. M. Robeson
Rudolf Roesler
Axel Sahlin
C. Schlachter
J. C. Shaw
Harold B. Smith
Walter B. Snow
K. J. Sunstrom
F. H. Taylor
J. W. Taylor
J. O. Emanuel Trotz
Charles A. Walker
A. Wallicks

BOOKINGS ON THE OFFICIAL VESSEL, VICTORIA LUISE

J. G. Aldrich
L. P. Alford
Chas. W. Baker
E. P. Bates
F. E. Bates
Geo. M. Bond
L. P. Breckenridge
Geo. M. Brill
W. C. Brinton
S. H. Bunnell
J. A. Bursley
B. G. Buttolph
H. E. Clifford
R. Conboy
Wm. C. Dart
F. W. Dean
A. C. Dickerman
J. M. Dodge
Geo. F. Felker
E. R. Fellows
F. A. Flather
E. L. Foucar
J. R. Freeman
L. G. French

A. A. Fuller	R. K. LeBlond	G. I. Rockwood
R. W. Fuller	J. W. Lieb, Jr.	J. W. Roe
H. L. Gantt	H. M. Leland	J. J. Ruckles, Jr.
P. W. Gates	F. R. Low	C. R. Schmidt
F. B. Gilbreth	H. H. Lucas	F. L. Schmidt
Kate Gleason	C. W. Lummis	P. B. de Schweinitz
A. H. Goldingham	W. W. Macon	W. Seligman
A. M. Greene	W. T. Magruder	M. M. Sibley
Jas. A. Hall	L. C. Marburg	A. Smith
Jas. Hartness	E. D. Meier	Jesse M. Smith
M. D. Hersey	S. L. Moore	Ambrose Swasey
H. J. Horstmann	A. H. Morse	W. H. Taylor
A. C. Jackson	F. F. Nickel	E. D. Thurston, Jr.
R. R. Keely	G. A. Orrok	W. R. Warner
E. E. Keller	H. G. Reist	S. T. Wellman
Wm. Kent	Calvin W. Rice	W. H. Wiley

Note.—About seventy ladies are also included in the official party.

THE SPRING MEETING

The members may look forward with anticipation to the coming Spring Meeting, to be held in Baltimore, May 20-23. This will be the first visit of the Society to this city and the cordiality of the invitation received from the members resident there, as well as the Engineers Club and the civic organizations, is evidenced by the fact that it was extended two years in advance of the date for the meeting.

The technical sessions have already been tentatively determined by the Committee on Meetings, and at a meeting of the Baltimore members, the Engineers Club and the civic organizations, held in Baltimore on December 19 and attended by the Secretary, the general scheme of social features was discussed. The Chairman of the Local Committee will be Layton F. Smith, past-president of the Baltimore Engineers Club.

Baltimore with its remarkable harbor and its nearness to Washington and Annapolis is a most attractive city in which to hold a convention, and the membership are assured of adequate and comfortable accommodations at the Hotel Belvedere, the headquarters selected. More than three hundred rooms are available and the hotel is most conveniently arranged in respect to meeting halls, accessibility, etc. As the date of the meeting comes within the height of the season in Baltimore, when the weather is ideal and the city is crowded with visitors, hotel accommodations should be reserved in advance and as early as possible, in order to insure against disappointment.

One of the excursions which will be included in the program laid out by the local committee will be a trip to Annapolis, one of the oldest cities in America, and hence of historical as well as patriotic interest. The trip will probably be made by boat, and the visitors will have an opportunity to see the grounds and buildings, on which fifteen million dollars have recently been expended, and to watch the midshipmen in various naval manoeuvres.

There will also be excursions to the hydroelectric plant at McCalls Ferry on the Susquehanna River, and to the various points of interest in Baltimore itself, such as the new sewerage disposal plant recently installed at an expense of twenty million dollars, the new system of municipal docks, as well as its principal industries, including sealing devices, canning and preserving, and tobacco.

CURRENT AFFAIRS OF THE SOCIETY

At a recent meeting of the Council the following were elected members of the Executive Committee for 1913: W. F. M. Goss, Chairman, Alex. C. Humphreys, Vice-Chairman, E. B. Katte, E. D. Meier, and George A. Orrok. Committee appointments were also announced as follows: Finance Committee, R. M. Dixon; Committee on Meetings, R. H. Fernald; Publication Committee, F. R. Low; Membership Committee, L. R. Pomeroy; Library Committee, serving on the Library Board of the United Engineering Society, Chas. L. Clarke, Alfred Noble, E. Gybbon Spilsbury, Leonard Waldo, Calvin W. Rice; House Committee, F. A. Scheffler; Research Committee, L. S. Marks, R. D. Mershon; Public Relations, George M. Brill.

LOCAL COMMITTEES

Committees have been chosen in the several cities where meetings are held at stated intervals, and the work outlined for the year in these various centers. In Boston, the following committee were elected at a recent meeting: Henry Bartlett, R. E. Curtis, H. N. Davis, W. G. Snow, A. L. Williston; in New York, the committee chosen consists of, F. A. Waldron, Chairman, Edward Van Winkle, Secretary, R. V. Wright, Treasurer, H. R. Cobleigh, and J. J. Swan. In San Francisco, W. F. Durand, T. W. Ransom, C. R. Weymouth, and R. S. Moore, are the committee chosen for the arrangements for the International Engineering Congress in 1915, preparations for which are now in progress.

COMMITTEE ON STANDARDS

The Committee on Myriawatt, H. G. Stott, A. F. Ganz and Carl Schwartz, which has recently coöperated with the American Institute of Electrical Engineers on this important question, is to be continued as a Committee on Standards, with a view to coöperating with this same organization in matters of mutual interest and importance. The conclusions reached on the subject of the myriawatt are published in this issue of The Journal.

CALVIN W. RICE, *Secretary.*

LIBRARY SEARCHES

An important work being done in the Engineering Societies Library is in the conduct of engineering searches, and information is available on a large number of subjects. These include, among many, lubricants and their testing; gears, skew bevel, helical and spiral; burners for liquid and gaseous fuels; kerosene and other oils used in gasolene engines; spring motors; gasolene-electric vehicles; electric welding; transportation of materials in manufacturing plants; luminator process of boiler feedwater treatment, etc.

As an example of the speed and thoroughness with which these searches are made, a member of the Society recently solicited a complete description of the various universities of the world, and received within a week 169 photographs, descriptions, etc., at a total expense of $47. In this search a delay of two days was caused by an accident on the part of the firm furnishing the photographs.

Searches which are on file in the Library may be obtained by paying the small cost involved in copying, and information as to new searches may be secured on application to the Librarian.

The members of the Society are invited by the American Institute of Electrical Engineers to attend the lectures.

STANDARDIZATION OF THE MYRIAWATT

At a joint meeting of the Society's Special Committee on Myriawatt with the Standards Committee of the American Institute of Electrical Engineers on December 23, 1912, the following resolutions were adopted after a very full discussion:

Whereas, the "myrowatt" or "myriawatt" was suggested as a convenient unit of power only 2 per cent larger than the most recently determined values of the "boiler horsepower," and

Whereas, a paper setting forth the advantages of the use of the "myriawatt" as a unit of power in dealing with the performance of steam boilers, steam engines, gas engines, steam and water turbines, was read before the annual convention of the American Institute of Electrical Engineers in Boston in June 1912, was discussed and was published in the Proceedings of the Institute, and

Whereas, The American Society of Mechanical Engineers has appointed a special committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper,

Be it Resolved, (1) That the two committees in joint session recommend in their respective societies the use of the "myriawatt" as unit of thermal or mechanical power, as indicated in the above-mentioned paper; and

(2) That the two committees also jointly recommend to their respective societies the exclusive use of the myriawatt in connection with boilers, producers, turbines and engines, and discontinue the use of the term "boiler horsepower."

The paper to which the committee refer is reprinted herewith from the Proceedings, through the courtesy of the American Institute of Electrical Engineers.

THE MYRIAWATT

By H. G. Stott and Haylett O'Neill

The object of this communication is to introduce a new unit of power which, if adopted, will afford a basis of comparison of all converters of energy, thermal and mechanical; and also will be international in its character, as it is merely a new multiple of the watt.

In American and European practice, at the present time, there are in use many empirical units, the use of any one of which is restricted to a distinct territory. A few of the more important ones are, horsepower, boiler horsepower, kilowatt, cheval à vapeur, pferde-kraft and poncelet. Obviously an engineer in

attempting to compare data from a foreign country, is compelled to face a confusion of terms, which usually can be made intelligible only by laborious calculations.

Again, in the United States there are in vogue such units as boiler horsepower and horsepower, which, while similar in sound, have no logical connection; and one has yet to find where the " horse " comes in.

With the rapid development in electrical measuring instruments, and, until recently, a corresponding lack of development in steam-flow measuring instruments, the term kilowatt has become more and more used as the one unit of power output.

The term became a necessity with the growing favor of steam turbines, and all direct-connected units where it is impossible to measure accurately the mechanical and the electrical power separately.

To form a connection between the boiler or producer output, the engine and generator output, the term " myriawatt," derived from the Greek " myria," meaning ten thousand, and the term watt, is proposed.

For the purpose of standardization, the British thermal unit, 1/180 of the heat required to raise one pound of water from 32 deg. fahr. to 212 deg. fahr. and the equivalent evaporation from and at 212 deg. fahr. (970.4 b.t.u.) is used (Marks and Davis).

From this, the following equivalents are obtained:

1 foot-pound	=	0.001286	b.t.u.
1 kilogram-meter	=	0.009302	b.t.u.
1 gram-calorie	=	0.0039683	b.t.u.
1 horsepower	=	2547	b.t.u. per hr.
1 cheval à vapeur	=	2512	b.t.u. per hr.
1 pferde-kraft	=	2512	b.t.u. per hr.
1 poncelet	=	3349	b.t.u. per hr.
1 kilowatt	=	3415	b.t.u. per hr.
1 boiler horsepower	=	33479	b.t.u. per hr.
1 myriawatt	=	34150	b.t.u. per hr.

Reduction of the myriawatt to the above units

1 mw.	=	34,150	b.t.u. per hr.
1 mw.	=	8,605,000	gram-calories per hr.
1 mw.	=	26,552,000	foot-pounds per hr.
1 mw.	=	3,670,900	kilogram-meters per hr.
1 mw.	=	13.410	horsepower
1 mw.	=	13.597	cheval à vapeur
1 mw.	=	13.597	pferde-kraft
1 mw.	=	10.197	poncelets.
1 mw.	=	10	kilowatts.
1 mw.	=	1.020	boiler horsepower

Reduction of all the above units to myriawatts or myriawatt-hr.

1 b.t.u.	$= 2.928 \times 10^{-5}$ mw-hr.
1 gram-calorie	$= 1.1621 \times 10^{-7}$ mw-hr.
1 foot-pound	$= 3.7662 \times 10^{-8}$ mw-hr.
1 kilogram-meter	$= 2.7238 \times 10^{-7}$ mw-hr.
1 horsepower	$= 7.457 \times 10^{-2}$ mw.
1 cheval à vapeur	$= 7.354 \times 10^{-2}$ mw.
1 pferde-kraft	$= 7.354 \times 10^{-2}$ mw.
1 poncelet	$= 9.807 \times 10^{-2}$ mw.
1 kilowatt	$= 1.00000 \times 10^{-1}$ mw.
1 boiler horsepower	$= 9.804 \times 10^{-1}$ mw.

The last two are practically the same, differing by only two per cent. The usual practice is to rate water-tube boilers on the basis of one boiler horsepower per 10 sq. ft. of heating surface.

With modern plants, notably those in marine service, operating from two to five times this rating, the ordinary method of determining nominal boiler capacity could be stretched 2 per cent without materially affecting the present rating: i.e., the boiler might be rated at 34,150 b.t.u. per hour for each 10 sq. ft. of heating surface, instead of at 33,479 b.t.u. per hour for each 10 sq. ft. of heating surface.

The myriawatt as a unit of boiler or producer output, and correspondingly a unit of input to all kinds of dynamical machinery, is fixed in value by the watt, and by its very sound gives a clue to its meaning.

To compare efficiencies of direct-connected units and eliminate the various factors of quality of steam, pressure and vacuum, the term "b.t.u. per kilowatt-hour" has been used. If we used the term myriawatt

$$\text{per cent overall efficiency} = \frac{10 \times \text{kilowatts output}}{\text{myriawatts input}}$$

Also, with the thermal efficiency of the engine known, the heating surface in the boiler room is determined (assuming the 10 sq. ft. rule), thus, two kilowatts per myriawatt input to an engine is equivalent to 20 per cent thermal efficiency of the engine and the heating surface in the boiler room equals kilowatts engine output $\times$ 10/2.

Obtaining an exact figure of the same with the boiler horsepower unit involves a tedious operation.

The efficiency of internal combustion engine-driven units of all cycles, such as Diesel, Brayton, Otto, etc., is determined by rating the heating value of the fuel in myriawatts; thus

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

With hydraulic machinery, again rating the water power input to the wheels in myriawatts:

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

Thus, in the term myriawatt lies a simple, logical and universal means of comparing outputs and inputs of all classes of energy converters, the meaning of which will be clear to all engineers wherever a piece of electrical machinery is to be found.

COMPARISONS IN EFFICIENCIES AND RATES OF OUTPUT WITH VARIOUS TYPES OF ENERGY CONVERTERS, IN TERMS OF THE MYRIAWATT

1 Boiler output:

Nominal rating = 600 boiler h.p.

Total draft head inches water gage	Boiler h.p.	Myriawatts
1.730	1375	1348

2 5000-kw. engine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
4977	17.2	20,160	1.70	17

3 5500-kw. high-pressure turbine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
8183	16.39	18,450	1.85	18.5

4 15,000-kw. engine—low-pressure turbine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
11,240	13.19	15,660	2.18	21.8

5 56-in. low head water-turbine:

Brake h.p.	Brake kw.	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Conversion eff. per cent overall
283	211	8.41	84.1

6 Steam plant efficiency:

Lb. coal per kw-hr.	= 2
b.t.u. per lb. coal	= 14,250
b.t.u. per kw-hr.	= 28,500
Kilowatts per myriawatt input to boilers	= 1.2
Plant efficiency	= 12 per cent

7 Gas power plant efficiency:

Kw. output	$\frac{\text{Cu. ft. gas}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
5200	145	14,220	2.4	24

BALTIMORE HIGH-PRESSURE FIRE SERVICE

By James B. Scott

ABSTRACT OF PAPER

The Baltimore high-pressure fire service, recently placed in operation, has several features which are departures from the design of similar systems in other cities.

For reducing the time element in reaching the scene of a fire the department is provided with high-speed automobile hose wagons, equipped with monitor nozzles, 3-in. hose and portable hydrant heads.

The hydrant heads are fitted with four permanently attached combination operating and regulating valves. By the movement of a small lever the pressure on each hose line may be independently regulated to any desired amount from complete shut-off to full hydrant pressure.

Flush hydrants are used, provided with bayonet joints for quickly attaching the portable heads. Hydrants are alternated on opposite sides of the streets and are generally located in the center of the sidewalks, to give an unobstructed sweep of the streets longitudinally, forming a water curtain in front of exposed property.

The gridiron is of lap-welded, rolled steel pipe with metal to metal universal joints. The electrical resistance of the joint is low, and by the use of a heavy asphalt coating, the rapid deterioration due to electrolytic action has been avoided. Branches are attached through welded necks. All valve bodies and specials are of cast steel. Leakage is almost nothing.

Steam driven crank and flywheel plunger pumping engines are used, provided with automatic speed and pressure regulators.

Boilers are covered with an air-tight steel plate housing, to reduce radiation losses during standby service. Coal burning furnaces are installed, with forced draft and mechanical stokers, having automatic control of air and fuel. Coal is supplied by gravity to the stoker hoppers from overhead bunkers. Feedwater regulators are included, with governors on the feed pumps. The station building is entirely fireproof, and if the crew should be driven out by a conflagration, the station could operate automatically for several hours.

Simplicity and reliability have been placed foremost in the design. The station possesses a large overload capacity beyond its rating. The total operating expenses and fixed charges are lower than with electrically operated pumps.

BALTIMORE HIGH-PRESSURE FIRE SERVICE

By James B. Scott, Baltimore, Md.

Member of the Society

The Conflagration of 1904.—The conflagration of 1904 was due to the simultaneous occurrence of an incipient warehouse fire gaining headway unobserved on a Sunday morning; a high wind; inferior building construction and inadequate fire fighting equipment.

2 During the first eight hours of the fire the wind was blowing from the southwest, after which it shifted 90 deg. to the northwest, causing the fire to advance with its broadside of 1500 ft. for a front. Although supplemented by engines from other cities, after the fire had got beyond control the operations of the department might be described as a skillful retreat, an engine and a truck being lost under falling walls because the retreat had not been sufficiently rapid. Dynamite was freely used by skillful operators, but was practically ineffective. The fire raged for 30 hours, covering 150 acres, causing a loss of $100,000,000 and finally burned itself out when the wind changed again to the north and drove the flames toward the open harbor.

3 There was no scarcity of the water supply. The topography of Baltimore shows elevations ranging from 6 to 460 ft. above mean low tide, and to prevent excessive pressures in the low lying sections or a deficiency in those higher up, the supply is divided into five separate services. The "low" and "middle" services are fed entirely by gravity, the three higher services being supplied by pumps and high storage reservoirs. Suitable by-passes are provided so that in an emergency any service can be supplied from the next higher. At the time of the conflagration there was available a total reservoir capacity of over 1,750,000,000 gal., in addition to pumps of 63,000,000 gal. capacity. At that time the consumption for domestic and industrial purposes was about 60,000,000 gal. daily, and the draft

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from the reservoirs for fighting the conflagration was approximately the same amount, or a trifle over 3 per cent of the available reservoir capacity. In addition to the reservoir draft, about two hours after the fire started the two 17,500,000-gal. pumps in one of the high-service pumping stations were by-passed into the "middle" or upper gravity service. The fire originated in the middle service district and shortly afterward extended into the low service district. As soon as this occurred the by-pass between the two was opened, and the pressure was maintained at 80 lb. during the remainder of the fire.

4 The operations against the conflagration demonstrated that, for effective fighting of a dangerous fire, large volumes of water must be delivered on the fire with the least possible delay, and at suitable pressures. To meet these requirements a separate high-pressure fire service was designed and installed, covering the greater portion of the congested value districts of the city.

5 *Characteristics of the Congested Value Districts.*—The corporate limits of Baltimore embrace an area of $31\frac{1}{2}$ sq. m., with a density of population of 17,729 per sq. m., a density greater than any other of the larger American cities. The congested value districts cover approximately 300 acres, the area at present covered by the high-pressure mains is about 175 acres, or assuming that the territory for 200 ft. outside the mains is protected, the high-pressure district may be considered to be 245 acres.

6 The elevations of the congested value districts vary from 6 ft. to 100 ft. above mean low tide, about one half of the area being below elevation 50. The pump centers at the high-pressure station are at about elevation 12.5.

7 The character of the building construction in the congested value districts varies from first-class modern fireproof structures to converted residences, except in the rebuilt burned district, where a better type of construction exists. In the districts in question all electric wires have been placed underground in conduits owned by the city, with the exception of the street railway trolleys. Before rebuilding the burned district, several narrow and congested streets were widened and plazas established around important public buildings, so that the conflagration hazard in that section has been considerably decreased.

DESIGN OF THE HIGH-PRESSURE SYSTEM

8 *The Time Element.*—High-speed automobile hose wagons are provided, housed at convenient locations, in order that the minimum

FIG. 1 MAP OF THE HIGH-PRESSURE DISTRICT

time possible may be consumed in reaching the scene of a fire after the alarm is received. Each wagon is equipped with a four-cylinder four-cycle motor of sufficient power to develop a speed of 30 m. an hr. through the streets of the city, with a load of 5000 lb. Each body is 50 in. by 34 in. by 12 ft. inside, and carries 2000 ft. of 3-in. hose. Each body is equipped with one 2000-gal. Morse Invincible monitor nozzle and two 1100 gal. monitors.

9 *The Pressure Element.*—The pressure required for effective work varies widely according as conditions demand the flooding out of a basement fire or fighting on the top floor of a modern skyscraper. At times both extremes may be required simultaneously.

10 To meet efficiently these conditions requires the maximum pressure to be available at each hydrant, with means for the separate control of the pressure on each hose line. The specifications called for a combination operating valve and regulator capable of adjustment from shut-off to 50, 75, 100, 125, or 150 lb., or if desired, to the full line pressure of 300 lb. The pressures were to be plainly marked on the valve by notches to be used by the operator as a guide for setting the handle. Regulators were to hold the pressures steadily within 10 lb. of the set amount, whether the play pipe were open or closed. The regulator was also to be provided with a lock whereby the handle could be prevented from passing the 150 lb. notch, but after unlocking could be moved to the full line position. When wide open under the maximum pressure of 300 lb. the valve was not to show a loss of head in excess of 15 lb. The hydrant head was to contain four horizontal outlets and one vertical outlet, each horizontal outlet to be provided with a regulator, and the complete head including four regulators was not to weigh over 110 lb. The head and regulators were to be designed for 300 lb. working pressure and were to be tested with a static pressure of 600 lb.

11 While the above requirements may seem simple enough, only one of the valves submitted by different makers met the requirements in all essential points, a regulator designed especially for the purpose by the Ross Valve Mfg. Co. of Troy, N. Y. (Figs. 2 and 3.)

12 The main regulating valve is inserted in an opening just over the hose connection, and is inclined outward at an angle of 20 deg. The opening is closed with a plate carrying a pilot valve and a guide for the main valve. The pilot valve with its diaphragm is covered with a spring chamber, the whole being held in place by cap screws. The main valve is balanced and is provided with a flat seat and leather face. The upper part of the main valve acts as an operating

piston, being provided with a cup leather packing. The pilot valve is balanced against the delivery pressure by the regulator springs, which are made double to secure a wide range of pressure in a short length. The top of the spring chamber is revolved by the operating handle attached to it, and being provided with a coarse square thread screw, less than one revolution is sufficient to give the full range of pressure on the springs from full open to closed. The pilot valve is held positively in the two extreme positions independently of the springs by stops at the top and bottom of the stem. The full hydrant pressure is admitted to the operating chamber of the main valve through a small tube projecting below the seat of the valve. This tube is extended in order to keep the entrance clear of the varying velocity near the valve seat, which would tend to vary the flow of water to the operating chamber. When the pilot valve is open, water wastes from the operating chamber, the pressure is lowered and the main valve is opened by the unbalanced pressure below. When the pilot valve is closed the full hydrant pressure is maintained in the operating chamber, and as the area of the operating piston is somewhat larger than the area of the main valve, the pressure is unbalanced in the opposite direction and the main valve is closed. Intermediate positions of the pilot valve are followed by corresponding movements of the main valve, maintaining the delivery pressure within a few pounds of the amount indicated by the notch at which the operating handle is set. The main valve when fully opened presents an unobstructed waterway. The entire mechanism is simple in design, easy to operate and has proved entirely satisfactory in service.

13 *Quantity of Water Available.*—The National Board of Fire Underwriters after a careful study of the situation recommended that a total delivery of 15,000 gal. per min. should be available within any area not exceeding 100,000 sq. ft., at a pressure of not less than 200 lb. at the hydrant. As installed, each hydrant has four $2\frac{1}{2}$-in. horizontal and one vertical outlet for mounting a monitor nozzle. At present the 3-in. hose is connected through reducer couplings, but in the future all hydrants will be equipped with 3-in. outlets and connections to $2\frac{1}{2}$-in. hose will be made through reducers.

14 The quantity of water which can be delivered through a hydrant is a function of the number, length and size of hose lines attached, and the diameter and type of nozzles. Assuming four lines of 3-in. rubber-lined hose each 100 ft. in length, and 200 lb. at the hydrant, with $1\frac{3}{4}$-in. smooth nozzles, each hydrant would de-

liver 3800 gal. per min., or the requirement of the underwriters would be met by four hydrants. At least twice that number of hydrants are available for every unit of area mentioned. If 2-in. nozzles were used, other conditions remaining the same, the discharge would be 4400 gal. per min. at a pressure of 86 lb. at the base of the play pipe, as compared with 108 lb. in the former case.

15 At present 226 hydrants have been installed, staggered on

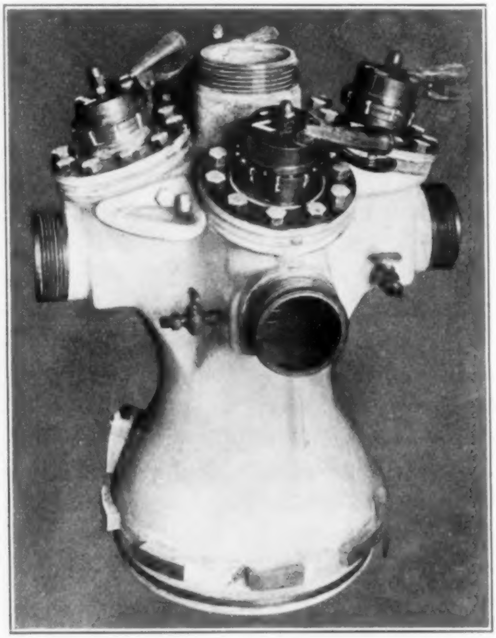


Fig. 2 Portable Head

opposite sides of the streets, averaging about 170 ft. lineal spacing. In addition to the normal locations at street and alley intersections, the fire chief placed a number of hydrants at special positions, to meet local conditions of exposure, extra hazard or specially congested values.

16 *Design of Hydrant.*—The type of hydrant to be used was given careful study. It was considered especially desirable in view of the experience gained in fighting the conflagration, to be able to place a monitor or special flat nozzle directly on the top of the hydrant, to form a water curtain for the protection of exposed property on the opposite side of the street. Street intersections form a

specially desirable location for such a purpose, but usually the corner of the footway is preëmpted for various other structures such as sewer inlets, lamp posts, trolley poles, police and fire-alarm boxes, etc. It was soon evident that if restricted to the ordinary post type of hydrant, it would be impossible to secure suitable loca-

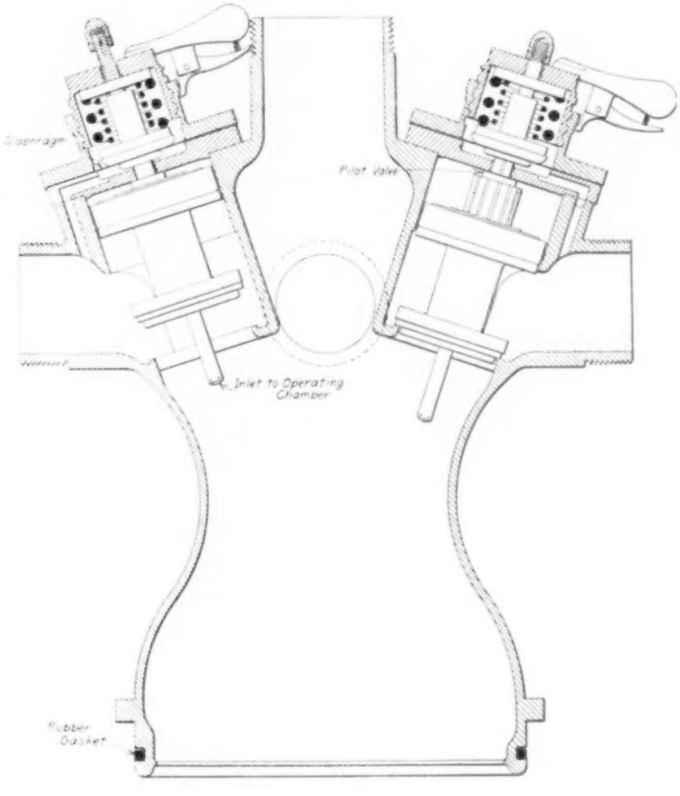


Fig. 3 Section of Portable Head

tions, and the water-curtain feature would have to be abandoned. The flush hydrant with portable head seemed to meet all the conditions admirably. By the use of this type, hydrants could be located almost without restrictions, either in the driveway or any part of the footway. The portable head was also admirably adapted to the use of the regulating valves on the hydrant, as the entire operating mechanism, other than the main valve, could be kept in the firemen's

quarters, instead of being exposed to frost or other injuries on the street.

17 The portable head as designed, complete with four regulating valves, weighs 110 lb. In order to provide against any delay in attaching the head to the hydrant, a special "bayonet" joint was designed (Fig. 2). The head slips loosely into the barrel of the hydrant, and by a twist of $22\frac{1}{2}$ deg., a series of interlocking lugs on the head and barrel engage each other, and the full section of these bronze lugs is in shear to resist the water pressure. The water joint is made by means of a square soft rubber packing ring placed in a square groove on the outside of the lower portion of the head. The groove is somewhat larger than the packing ring, and at very low pressures water leaks past the ring. At higher pressures, however, the water presses the rubber closely against the barrel, and the joint is absolutely tight at all pressures between 20 and 1000 lb. The action is entirely automatic, there being no screws nor glands of any kind to be manipulated. When the water is shut off, the ring contracts and the head can then be lifted out of the barrel without the slightest resistance. To illustrate the extreme simplicity of the device, and the ease of handling, a recent test by the engineers of the National Board of Fire Underwriters may be cited. The head and operating key were laid in the center of the street, 20 ft. away from the hydrant. Two firemen selected at random, picked up the head and key, ran to the hydrant, removed the two loose covers, placed the head in position and turned the water on, all in the space of 18 seconds by a stop watch.

18 A small cast-iron cover is laid over the top of the barrel to protect it from dirt and injury, and over this is placed a larger cast-iron cover flush with the pavement. As practically all the hydrants are located on the sidewalks the cover is made quite light, and if it should become frozen in, it can be broken instantly by a blow from the operating key.

19 The hydrant proper is designed for a clear waterway of 28 sq. in. through the main valve. The main valve closes with the pressure, and an auxiliary is provided, actuated by the main valve stem. This auxiliary valve opens in advance of and equalizes the pressure before the main valve starts to open. A drip valve is arranged so that as the main valve opens the drip is closed and vice versa, but both valves cannot be open at the same time. Both the main and auxiliary valves have conical leather faces and bronze seats. The

barrel of the hydrant is of soft grey iron, and all nuts and fittings, stuffing-boxes, etc., are of bronze. The main valve stem is Tobin bronze, and the operating spindle is of forged steel. All pressure parts are designed for a working pressure of 300 lbs. with a factor of safety of twelve. After erection a field test of 600 lbs. was made.

HIGH-PRESSURE PIPE LINES

20 *General Plan.*—The general plan of the system is a gridiron of

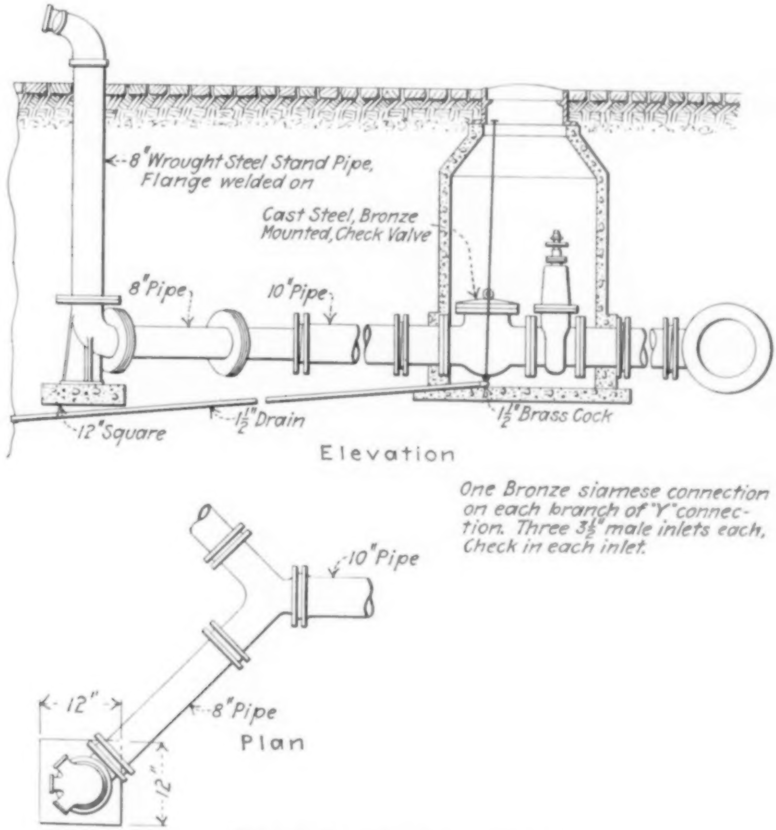


Fig. 4 Fireboat Connection

16-in. mains crossing at intervals of approximately 1200 ft. in each direction, with 10-in. laterals in the intermediate streets spaced approximately 400 ft. apart. A 10-in. branch is provided at the harbor front for connection with the fireboats (Fig. 4). All hydrant

branches are 8 in. There are no dead ends on mains or laterals in the entire system, with the exception of an extension on one street which will be connected up at the next addition to the system. From the pumping station two 24-in. mains discharge into the intersections of the 16-in. mains. In the pumping station the 24-in. mains are looped around the rear of the pump foundations, thereby avoiding dead ends and by equalizing the stresses render unnecessary any heavy anchorages. Individual 14-in. pump discharges deliver directly into the 24-in. mains through welded necks. Three 24-in. valves and an 18-in. cross connection in the station, serve to sectionalize the large main, so that any portion may be cut out without putting more than one pump out of commission. A large rolled steel air chamber 30 in. in diameter by 20 ft. high is placed on each 24-in. discharge main.

21 *Cast-Iron versus Steel Pipe.*—For the service in view it was believed that cast-iron pipe, usually employed for city water mains, was not a scientific application of material for the stresses involved. On the other hand, commercial rolled steel lap-welded pipe meets the structural conditions much more satisfactorily. With this material the pipe system becomes an engineering structure, all tensile and bending stresses are taken up by the pipes themselves and the system would be entirely safe if laid on the surface of the ground.

22 The principal objection urged against the use of steel for this purpose is the liability to corrosion, especially when complicated by electrolysis in city streets. After a careful study of the problem, it was decided that the advantages of this material outweighed the objections, for the following reasons:

a If the entire pipe system had to be renewed every ten years, the steel would still be more reliable and hence more desirable than cast iron, as the latter is liable to fail by breakage without previous warning. When deterioration of the steel pipe does occur, it makes itself known by increase of leakage, which can be detected and repairs made gradually, as occasion offers. By way of reductio ad absurdum it might be argued that if absence of corrosion be the controlling feature in the selection of a material, a glass pipe would be the ideal, as it would last forever if not broken by shock or bending stresses.

b The study of corrosion of steel has reached a point where it is possible to say that corrosion is not inevitable, but

is due to more or less direct violation of certain well defined principles. If steel can be protected from the simultaneous action of moisture, air and acids, the causes of rusting or corrosion are to a great degree removed, regardless of the particular chemical theory held by the investigator. Protecting the steel from the action of these three agents is mainly a mechanical proceeding. A permanent, impervious, elastic coating, which will adhere closely to the metal is the requirement. High-grade asphalt applied when both the steel and the coating are hot and clean, seems to meet these conditions satisfactorily. The specifications for the chemical composition of the asphalt used were very exacting. Among other conditions it was required that a cubic centimeter of the material should show no action when exposed for one year in any or all of the following solutions: 25 per cent hydrochloric acid, 25 per cent sulphuric acid, 25 per cent potassium cyanide, 25 per cent caustic soda, saturated solution of ammonia. The pipes were thoroughly cleaned and heated to a temperature of 300 deg. fahr. and while hot were dipped vertically in the bath of asphalt, which was maintained at a temperature of from 350 to 400 deg. fahr. The pipe was held in the bath for a sufficient length of time and was then drawn out slowly, at the rate of 5 to 10 ft. per min., so that a coating of 1-32 in. thickness was evenly distributed over the entire surface of the pipe. Any damage to the coating during shipment or erection was repaired by the application of the same material dissolved in a suitable solvent, and applied in several coats at intervals, until a satisfactory thickness was obtained. All bolts and nuts were dipped in the same solution before being inserted in the flanges.

c Electrolysis is due to an electrical difference of potential between the metal and the earth in contact with it, of sufficient magnitude to cause a current flow from the pipe to the earth. Since the conflagration of 1904 the City of Baltimore has required all electrical wires to be placed in the municipal conduits, and to protect the cables from electrolytic action the city's electrical commission made a careful study of the local situation. As

a result the street railway was compelled to rebond a large part of its tracks, copper cables being carried around all special work. In addition a supplementary copper return covering the entire district was installed, consisting of three bare copper cables having an aggregate cross-section of 6,000,000 circular mils. An entirely separate copper return was also installed as a protection for the cable sheaths, nothing but lead cables being bonded to this. The cross-section of this latter varied from 1,000,000 to 6,000,000 circular mils. As a result of this large amount of copper in the return circuit, the difference of potential between the various underground structures has been reduced to a nominal figure.

The special joint designed for the Baltimore Steel pipe line has a resistance equal to 6 in. of the pipe on the 10-in. size, and equal to 9 in. on the 16-in. pipe. The resistance of a bell and spigot lead joint is often equal to 4 or 5 ft. of the pipe.

d Finally, the current flow from the pipe to the earth may be made very small if a high resistance covering be placed around the entire pipe system. In the present instance the asphalt coating furnishes the necessary high resistance envelope.

23 While it is still too early to offer definite evidence regarding the life of the pipe in question, pipes which have been in the ground for two years have recently been exposed by excavations for other work, and have shown absolutely no signs of deterioration, the coating being in perfect condition.

24 *Pipe.*—The specifications called for lap-welded pipe made of soft open hearth steel having the following qualities:

	Per Cent
Carbon, not exceeding	0.10
Phosphorus, not exceeding	0.04
Sulphur, not exceeding	0.05
Manganese between	0.35–0 45

Ultimate tensile strength between 50,000 and 55,000 lb. per sq. in.; elastic limit at least ½ ultimate; elongation not less than 20 per cent in 8 in.; cold and quench bend 180 deg. flat.

25 The weld in the lap was to be perfect and capable of standing the strains incident to the manufacture of bends and forming of joints, without distress or rupture.

26 The thickness of pipe, in inches, was as follows:

24 in. Outside Diameter	½
16 in. Outside Diameter	$\frac{7}{16}$
10 in. Inside Diameter	$\frac{7}{16}$
8 in. Inside Diameter	$\frac{7}{16}$

27 Bends were generally of a standard radius of 5 diameters of pipe. Length of pipe, in feet, laid was:

24 in.	1,275
16 in.	17,052
10 in.	28,229
8 in.	7,137
Total	53,693 = 10.2 miles

28 *Joints.*—For the present service it was desired to avoid the use of rubber gaskets, which would tend to increase the electrical resistance of the joint. Copper gaskets or other metals dissimilar to the metal of the pipes, in the presence of moisture and the acids or salts of the earth, would form a voltaic cell, and tend to increase the corrosion due to electrical action. A joint was therefore designed to avoid altogether the necessity for a gasket or joint cement of any kind.

29 The Baltimore design is a form of universal joint (Fig. 5). The end of the pipe is flanged out into a bell forming a zone of a sphere. A soft cast-iron ring is accurately turned in the shape of a torus, having the same curvature on its exterior surfaces as the interior of the bell on the pipe ends. Loose flanges are placed on the pipe back of the bell, and when bolted up, draw the pipe bells up on the torus ring (Fig. 6). The pressure secured by the wedging effect on the spherical surfaces is enormous. If the curve of the surfaces be too flat, the metal of the pipe may be cold rolled, and the flanges may be pulled over the ring. By suiting the degree of the curvature to the diameter of the pipe, a safe combination is secured, and with the proper thickness of loose flange, a joint is secured which is absolutely water tight until pressures are reached which exceed the elastic limit of the pipe or bolts. On the 10-in. size this pressure is about 2200 lb. per sq. in. In the field testing, during the installation of the pipe, the specified test pressure was 600 lb., but during the early stages of the work, this pressure was often largely exceeded.

30 The joints are designed for a deflection of 10 deg., or about 3 ft. 6 in. in a 20-ft. length. On the 10-in. size this amount of deflection is easily obtainable, but on the larger sizes a smaller amount was used, though sufficient to be of considerable value in city work. A

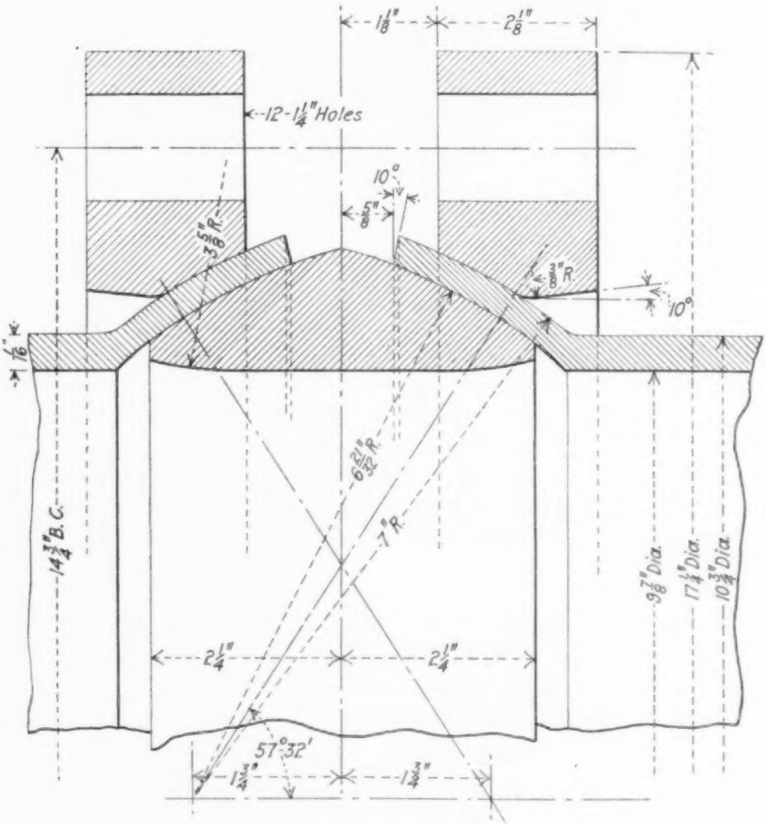


Fig. 5 Detail of 10-In. Pipe Joint

line of 10-in. pipe was made up of seven 20-ft. lengths, and while the pressure was on, one end of the line was raised 5 ft. by means of a crane, as shown in Fig. 7. While suspended in the air, supported only at the two ends, 140 ft. apart, there was practically no leakage at any of the joints. It is evident that at least that amount of trench might be washed out without interfering with the operation of the pipe system in the least degree. In laying the pipe it was possible to deflect it to pass an obstruction and in one instance, after the com-

FIG. 6 VIEW OF PIPE JOINT AND WELDED NECK

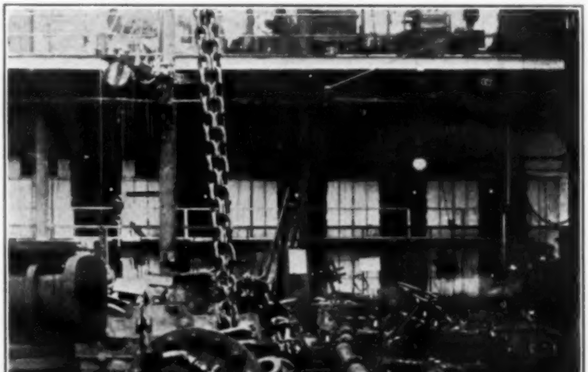


FIG. 7 SHOP TEST OF PIPE JOINT

pletion of the work, owing to a change of grade in the sidewalk, a hydrant branch 50 ft. long was jacked up 5 in. at one end, simply by loosening the bolts at one joint. Upon tightening these bolts, the line tested free of leaks at 600 lb.

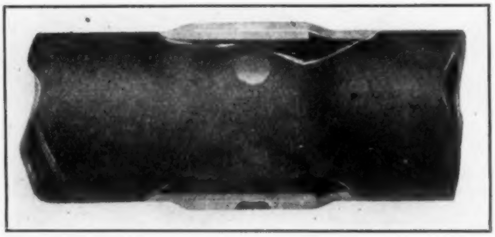


Fig. 8 Detail of Straight Line Weld

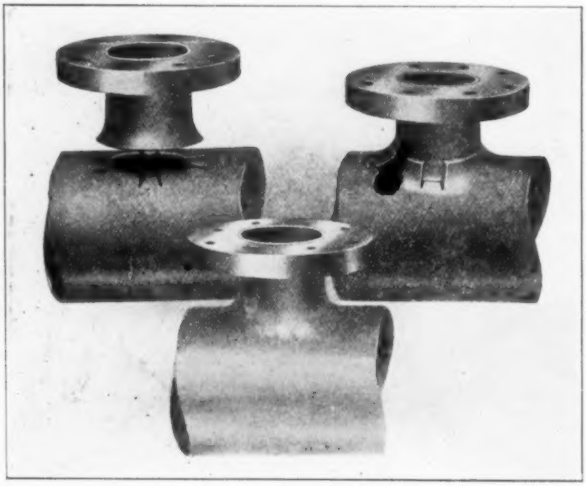


Fig. 9 Detail of Welded Neck

31 The fact that the pipe was laid in 20-ft. lengths means that the number of joints was reduced 40 per cent in comparison with cast iron.

32 For deflections greater than could conveniently be made by the joints, pipe bends were used. A bending table was installed on the work by the contractor, and about 1500 bends were made, or 150 per mile of pipe laid. Bends of 16-in. pipe and smaller were made

on the work, the 24-in. bends were made at the factory before shipment.

33 For make-up pieces at intersections and in blocks between valves or tees already installed, straight line welded joints were used. A special joint was devised for this service, made up as follows: The end of one pipe was accurately expanded sufficiently to permit of its being shrunk over the end of the pipe to which it was to be joined. Holes were cut around the circumference of the outer pipe or bell, and after being heated it was shrunk on in place. The

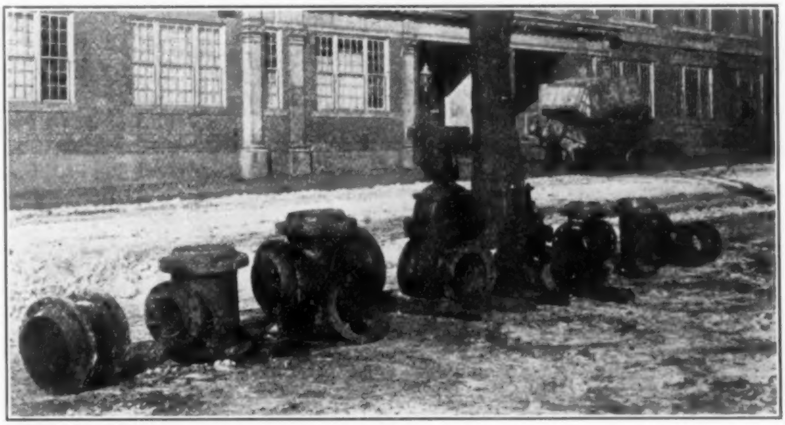


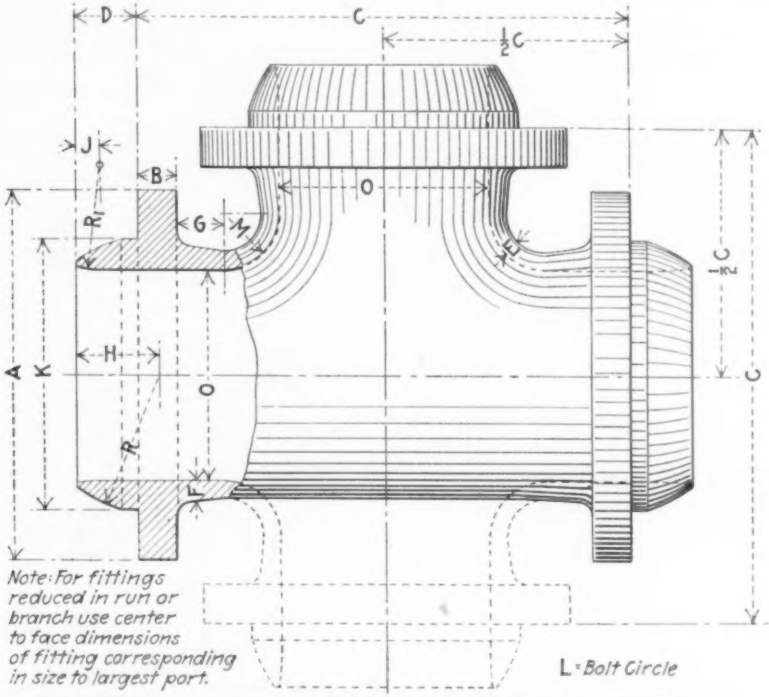
FIG. 10 CAST STEEL SPECIALS

holes were then flowed up with metal by the oxy-acetylene blowpipe, and the end of the bell was also welded to the enclosed pipe. With this type of joint the weld is in shear and not in tension, and it is entirely feasible to make bends in the pipe with the weld in the arc of the curve. Approximately 1500 of these straight line welds were made on the work, or about 150 per mile of pipe (Fig. 8).

34 *Flanges.*—The loose ring flanges were of medium open hearth steel, ultimate tensile strength 60,000 to 68,000 lb. All flanges were accurately machined and were drilled to template.

35 *Fittings.*—The use of steel pipe made it possible to reduce the number of fittings to a minimum. The hydrant branches were made by welding necks to the mains and laterals. A special neck weld was used, made up as follows: A hole was cut in the pipe, smaller than the size of the neck, and radial cuts were made forming four narrow lugs which were left projecting into the hole. The wider alternate

lugs were bent back to make an opening large enough to receive the neck piece. The smaller straight lugs formed a support for, and held the neck rigidly in place during the welding process. The whole joint was then flowed with metal by an oxy-acetylene blow-pipe, forming a joint as strong as the original pipes (Fig. 9).

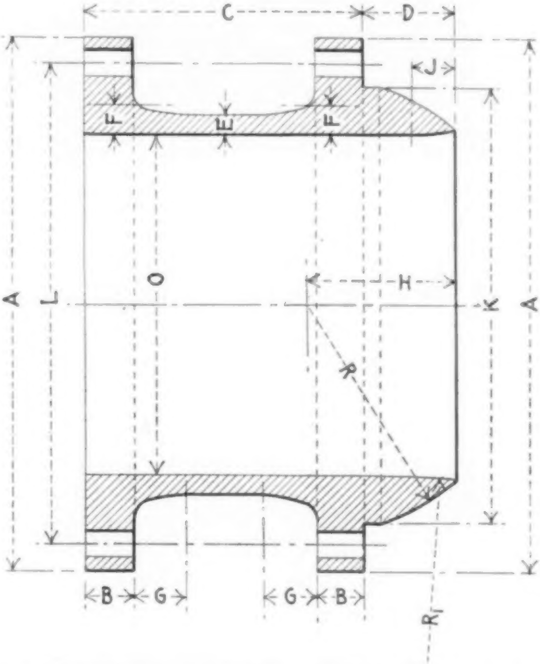


SIZE	A	B	C	D	E	F	G	H	J	K	O	R	R_1	L	M	BOLTS		
																NO.	DIA.	HOLE DIA.
10"	17 1/4"	2 1/8"	23 1/2"	3"	13/16"	1 1/8"	2 1/4"	4"	1 1/8"	12 27/32"	10"	6 21/32"	3 5/8"	14 3/4"	2 5/8"	12	1 1/8"	1 1/4"
16"	23 1/2"	2 1/2"	30"	4 3/8"	7/8"	1 1/4"	2 1/2"	6"	1 1/2"	20 13/32"	15 1/8"	9 29/32"	6 1/4"	21"	2 3/4"	16	1 1/8"	1 1/4"
24"	33"	2 3/4"	41"	3 7/8"	1 1/16"	1 1/2"	3"	8 3/8"	2 1/4"	27"	23"	14 19/32"	7"	30"	3"	24	1 1/4"	1 3/8"

FIG. 11 DETAIL OF TEES AND CROSSES

36 The only specials required were the tees and crosses at the intersections of the gridiron, and a valve connection piece used to give a straight face flange at the valves. By the use of the latter it was possible to use standard commercial valves, and the valves may be easily removed when necessary (Figs. 10, 11, 12). All fittings were made of low carbon open hearth cast steel.

37 *Valves.*—All valves are double-disc parallel seat gates. Bodies are low carbon open hearth steel of the same specifications as for fittings. Bonnets, discs, gearing brackets, glands and packing boxes are of semi-steel. Stems are of Tobin bronze, not less than 53,000 lb. tensile strength. Seats, wedge mechanism and glands are of



SIZE	A	B	C	D	E	F	G	H	J	K	R	R_1	O	L	BOLTS NO.	BOLTS DIA.	BOLTS HOLE DIA.
8"	$14\frac{3}{4}$"	$1\frac{7}{8}$"	$10\frac{1}{2}$"	$2\frac{15}{16}$"	$\frac{3}{4}$"	$1\frac{1}{8}$"	$2\frac{1}{4}$"	$3\frac{1}{4}$"	1"	$10\frac{9}{16}$"	$5\frac{1}{4}$"	$3\frac{1}{2}$"	$7\frac{3}{4}$"	$12\frac{1}{4}$"	8	$1\frac{1}{8}$"	$1\frac{1}{4}$"
10"	$17\frac{1}{4}$"	$2\frac{1}{8}$"	$11\frac{1}{2}$"	3"	$\frac{3}{4}$"	$1\frac{1}{8}$"	$2\frac{1}{4}$"	4"	$1\frac{1}{8}$"	$12\frac{27}{32}$"	$6\frac{21}{32}$"	$3\frac{5}{8}$"	$9\frac{7}{8}$"	$14\frac{3}{4}$"	12	$1\frac{1}{8}$"	$1\frac{1}{4}$"
16"	$23\frac{1}{2}$"	$2\frac{1}{2}$"	13"	$4\frac{3}{8}$"	$\frac{7}{8}$"	$1\frac{1}{4}$"	$2\frac{1}{2}$"	6"	$1\frac{1}{2}$"	$20\frac{13}{32}$"	$9\frac{29}{32}$"	$6\frac{1}{4}$"	16"	21"	16	$1\frac{1}{8}$"	$1\frac{1}{4}$"
24"	33"	$2\frac{3}{4}$"	$14\frac{1}{2}$"	$3\frac{7}{8}$"	$1\frac{1}{16}$"	$1\frac{1}{2}$"	3"	$8\frac{3}{8}$"	$2\frac{1}{4}$"	27"	$14\frac{19}{32}$"	7"	23"	30"	24	$1\frac{1}{4}$"	$1\frac{3}{8}$"

Fig. 12 Detail of Valve Connecting Piece

bronze. The 16-in. and 18-in. valves are geared. All street valves are provided with a stem nut, and a forged steel key is placed in each valve box. An interlocking arrangement is provided so that the key can be removed from the nut only when the valve is wide open. This prevents the valves being left closed or opened only a few turns, except in an emergency or intentionally, as the valve box

cover cannot be replaced while the key is on the nut. The 24-in. valves are in the pumping station and are hydraulically operated. All valves were subjected to a shop test of 800 lb. when open, and 600 lb. when closed.

38 *Valve Boxes.*—The street valves are treated as pieces of mechanism, subject to derangement, and hence are placed in concrete boxes or manholes, 42 in. inside diameter, where they can be

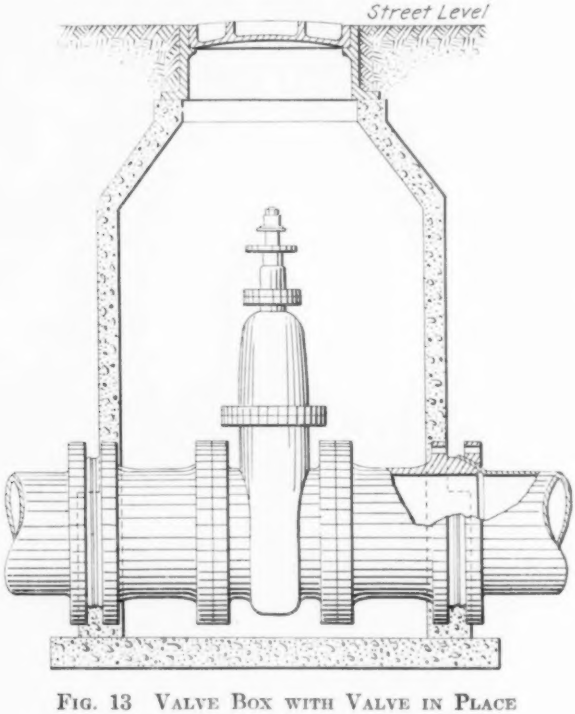


Fig. 13 Valve Box with Valve in Place

inspected and repaired without disturbing the street paving The floor was first laid of plain concrete, with suitable drainage connection; then the section enveloping the pipe or fitting was laid up with concrete blocks molded to the standard radius. The upper clear section was built of reinforced concrete rings, laid up without mortar, as they are provided with interlocking projections on the top and bottom faces, which make the rings self-centering. The upper portion is made of conical shaped rings, forming the roof, and supporting the cast-iron cover frame. The blocks and rings were made up in quantities in metal molds and seasoned before being used. They

were quickly and easily assembled in the trench by unskilled labor. The holes were back-filled and the street repaved in a remarkably short time, an item of considerable importance in a business thoroughfare as there was no time required for setting of the concrete. (See Figs. 13 and 14).

FIG. 14 CONCRETE VALVE BOX MADE UP

LOW-PRESSURE WATER SUPPLY

39 Two separate 40-in. mains from two different river systems, run direct to and form the normal supply for the high-pressure pumping station. The normal pressure available with the high-pressure draft included is from 30 to 50 lb., but if by-passed from the middle or high-service mains, the pressure can be carried at 70 lb. A 30-in. cast-iron branch is taken to the station where it changes to a 30-in. rivetted steel pipe inside the building.

40 An auxiliary supply of brackish water from the harbor may

be secured through a reinforced concrete conduit 3 ft. sq. inside. The conduit is provided with a large screen chamber at the dock, and has fine and coarse screens sliding in inclined frames, and both in duplicate, so that one set of each can be in service while the other set is out for cleaning. The screen chamber is also provided with stop logs so that the chamber and conduit can be pumped dry for cleaning out sediment. At the station end the conduit terminates in a large suction chamber located beneath the basement floor and between the pump foundations. The dimensions of this chamber are 8 ft. wide, 7 ft. deep and 70 ft. long. The gravity suction pipes enter the suction chamber through cast-iron thimbles built into the floor of the basement, as the basement floor is 8 or 9 ft. below flood tide level.

41 A by-pass from the high-pressure discharge main is led into the suction chamber for flushing it, and also forms a convenient discharge for the pumps during tests.

INSTALLATION OF PIPE LINES

42 *Tunnels.*—A considerable amount of tunneling was done, especially at street intersections, where double track crossings of the street railway were frequently encountered. On several of the busiest streets it was found necessary to tunnel for many blocks at a stretch. In a large number of instances it was thought desirable to tunnel for the hydrant branches, as the hydrants being staggered on opposite sides of the street, it was necessary on every alternate hydrant to cross the street, thus crossing also the railway tracks, pipes, sewers, electric conduits, etc. A segregation of these tunnels into groups is as follows:

	Lineal Feet
Intersections	5122
Straight line	4623
Hydrant connections	2630
Total tunnels	12,375

43 *Leakage.*—For field tests during the installation of the pipes, the contractor furnished a portable testing set consisting of a 3-h.p. 4-cycle gas engine, driving through a Morse chain a triplex plunger pump of a capacity of 5 gal. per min. at a pressure of 1000 lb. per sq. in. Each street section between valves was tested as the work was installed, and made absolutely tight, at the specified pressure of 600 lb. The section to be tested was filled from the ordinary fire

hydrants, after which the test pump was connected through a 1-in. flexible steel hose. In the early stages of the construction, the workmen would frequently carry the pressure up to 800 lb. and sometimes to 1000 lb., to show interested spectators what the new joint would stand. Afterwards a relief valve set for about 610 lb. was placed on the pump, and the testing became almost automatic.

44 After the pipe lines had been completed, but before the system had been put into commission, a pressure of about 300 lb. was put on the pipe lines by the main pumps. There being no hydrants open, the water was being wasted through a by-pass to reduce the pressure. A suggestion was made to close the pipe system off from the pumps to determine how long the pressure would remain. The main 24-in. valves were accordingly closed, while the pressure was at 125 lb. After a lapse of 16 hours the gage registered 95 lb., indicating that the leakage was practically nothing.

45 A duplex pump of 1000 gal. capacity was installed to keep up the pressure and take care of the leakage on the system. Since the equipment has been put into regular service it has been necessary to keep the by-pass valves open continually on this pump in order to permit the plunger to move.

CHOICE OF MOTIVE POWER

46 *General Considerations.*—In the preliminary studies for the project, careful attention was given to the design of similar plants in other cities, notably New York and Philadelphia. In the former, as is well known, electric driven centrifugal pumps are used. In Philadelphia, gas engine driven, geared triplex plunger pumps were installed. In the following discussion it should be remembered that local conditions often exercise a controlling influence in the decision as to the best form of motive power for such a plant.

47 In Baltimore the fundamental principle governing the design of the entire project was considered to be reliability under the most adverse conditions liable to be encountered. When it is considered that the safety of hundreds of millions of dollars worth of property is dependent upon the accurate functioning of each element, it is evident that no considerations of economy, either in first cost or operating expense, should be allowed to enter, if simplicity and certainty of operation are thereby subordinated.

48 *Gas Engines.*—The gas engine is subject to certain limitations, which in the case of fire service, place it at a distinct disadvantage.

a The load factor of the service is extremely low, being less

than 5 per cent per annum, so that the opportunity to profit by the high fuel economy is negligible.

b Inability to carry more than a small percentage of overload.

c In the hands of expert operators, a well designed modern gas engine is perhaps subject to no more accidents or delays than is a steam equipment, but certainly it is not subject to any *less* than steam. On the contrary, however, in the hands of operators of only average intelligence or experience, the number of apparently trivial causes which can result in serious delays or damage is surprisingly large in a gas engine plant. In the case of a municipal plant of this type it is useless to plan for ideal operating conditions, or to assume that only the highest grade operating force will be employed.

49 *Electric Motors.*—In spite of its many known advantages, a large electrical distributing system is essentially in unstable equilibrium, and subject to complete interruption from very slight causes, either natural or malicious. Dependence for prompt renewal of the service after a shutdown must be placed in duplicate lines and equipment in the stations. But even with these a considerable period must elapse before large electrical machines can be started up and brought into synchronism. A delay of this character during the first critical minutes of a bad fire would be fatal to the usefulness of an important fire fighting system. The fact that a vital feature of the fire fighting system would be under the control of employes of an outside corporation and not subject to the discipline of the fire department, with the possibility of a conflict of authority at a crucial moment, are all matters that must be considered.

50 Like the gas engine, the electric transmission, especially the underground system, requires for its commercially profitable conditions a high load factor, but for a different reason. To justify the large investment needed, requires a uniform load as near as possible to its capacity, in order that the fixed charges shall not be out of proportion to the earnings. Owing to the extremely low load factor of a fire station, its load is a very "undesirable" one to a commercial electrical supply corporation, unless a "demand" charge is made sufficient to justify holding in reserve a definite proportion of the entire equipment from the coal pile to the electric cables. Electrical plants require the installation of sufficient equipment all along the line to supply the maximum annual peaks. As a fire is no respector of anybody's peaks, it follows that a fire station load demands its

own separate power plant investment, whether the equipment is located in a commercial central station, or in an isolated plant for its own use.

51 A commercial plant is designed with a definite load factor in view, ranging usually from 30 to 50 per cent. For these conditions the most efficient equipment is justified, with all the refinements of modern fuel and labor saving auxiliaries in a large plant. If a load factor of only 5 per cent had been imposed, however, a very different type of equipment would have been selected, at a very much smaller investment.

52 The various links in the chain of an electrical supply equipment (not considering a long distance transmission) would be as follows:

a Coal handling apparatus
b Boilers and auxiliaries (stokers, stacks, economizers, heaters, etc.)
c Steam turbines and auxiliaries
d High-tension generators
e High-tension switching apparatus
f High-tension cables

and at the receiving end

g High-tension switches
h High-tension motors
i Centrifugal pumps

53 If a long distance transmission were included, there would be added step-up transformers, aerial lines, a substation with step-down transformers and switching apparatus. If low-tension motors were used, additional transformers would be required.

54 An isolated steam pumping station, designed for the purpose, eliminates at once five of the above links, namely, items *d*, *e*, *f*, *g* and *h*, and concentrates the entire operation in one building, under the direct control of the fire fighters themselves.

55 *Finances of Steam and Electrical Operation.*—Expressed in dollars and cents the argument becomes as follows:

Electric Pumps (New York Type)

Investment

5 motor driven pumps (rated capacity 3000 gal. per min.), switchboard, etc.	$112,500	
Building and pump foundations	84,000	
		$196,500

Operation			
Maintaining pressure continually			
8760 hr. less 100 hr. =			
8660 hr. at 100 kw		866,000 kw-hr.	
Fire service, 100 hr. per annum			
3150 kw. demand		315,000 kw-hr.	
		1,181,000 kw-hr.	
Service charge, maximum demand =		3150 kw.	
Central station investment, 3150 kw. at $75		$236,000	
Underground cable (Baltimore conditions)		40,000	
Cash requirements		276,000	
Underwriting at 90		31,000	
Total investment			$307,000
Fixed charges on $307,000			
Interest	at 5 per cent		
Depreciation	at 5 per cent		
Profit	at 5 per cent		
Total	15 per cent	$46,000	
Underground conduits, duct rental (Baltimore conditions)		1,300	
Total service charge			$47,300
Operating expenses			
Service charge		$43,700	
Meter charge, 1,181,000 kw-hr. at 1 cent		11,810	
Salaries, station operating force		10,650	
Supplies, lubrication and repairs		1,000	
			$67,160
Fixed charges on $196,500			
Interest at 4 per cent		$7,860	
Depreciation at 5 per cent		9,825	
			17,685
Total annual expense, electrical plant			$84,845
STEAM PUMPS			
Investment			
Four 4000-gal. pumps and auxiliaries		$86,000	
Boilers and auxiliaries		70,000	
Piping, steam and auxiliary water		30,000	
		$186,000	
Building and machinery foundations		125,000	
			$311,000

Operation		
Coal consumption		
Banking fires, 8760 hr. − 100 hr. = 8660 hr. = 360 days at 6 tons per day	2160 tons	
Fire service, 100 hr. per annum at 5 tons coal per hour	500 tons	
Total	2660 tons	
Operating expenses		
Coal, 2660 tons at $3.30	$8,778	
Salaries, station operating force	13,350	
Supplies, lubrication and repairs	2,000	
		$24,128
Fixed charges on $311,000		
Interest at 4 per cent	$12,440	
Depreciation at 5 per cent	15,550	
		27,990
		$52,118
SUMMARY		
Total annual expense, electrical plant	$84,845	
Total annual expense, steam plant	52,118	
Total annual saving		$32,727

This saving capitalized at 9 per cent represents an investment by the city of $363,630, considerably more than the first cost of the steam plant in the above comparison.

STEAM PUMPING STATION

56 *Pumps.*—The Baltimore plant is designed for four main units of 4000 gal. per min. rated capacity, at a piston speed of 300 ft. per min. and making 50 r.p.m. Three main engines have been installed and are in operation at present; the fourth unit will be added in the near future (Fig. 15).

57 In line with the policy of designing all parts of the system with a first requisite of simplicity and reliability, the main units each consist of a horizontal, twin, simple, non-condensing, crank and fly-wheel, plunger pumping engine. The water ends are attached directly to the engine frames, at opposite ends from the steam cylinders, the crank shaft being in the center (Fig. 16).

58 The steam cylinders are fitted with standard Corliss valve gears, having double eccentric long range cut-offs. The cut-offs of

both cylinders are under the direct control of the speed and pressure regulators, and are also provided with hand control.

59 Each engine was liberally designed for a continuous working pressure of 300 lb. per sq. in. on the water ends, with a test pressure of 600 lb. static. Injection parts were designed for a variation of pressure from 70 lb. direct to a suction lift of 15 ft. of salt water. All steam parts were designed for maximum working pressure of 200 lb., but the normal working pressure is only 125 lb.

60 Each engine is fitted with speed and pressure governors. The speed governor is driven by a noiseless chain belt, and acts directly on the cut-off valves of both cylinders. The pressure governors are identical in principle with the regulating valves used on the hydrants, and were also furnished by the Ross Valve Mfg. Co.

61 The net effective valve area between the openings of the valve seats on each suction and discharge deck is 308 sq. in. or 220 per cent of the cross sectional area of the plungers. The valves are $3\frac{1}{2}$ in. in diameter and are composed of rubber with brass backing plates; the seats are of bronze, screwed into the valve decks on a taper and faced off after being placed in the decks.

62 *Auxiliaries.*—To take care of the leakage in the pipe system and maintain a pressure of 150 lb., as well as to provide for the first draft from the hydrants before the main pumps are in action, a 1000-gal. per min. pump was installed. This is a horizontal, duplex, direct-acting, compound, non-condensing, center-packed plunger pump, giving its rated capacity at a piston speed of 100 ft. per min. While the pump was designed for a normal working pressure of 150 lb. on the water end, and for 125 lb. on the steam end, all pressure parts were designed to withstand a continuous pressure of 300 lb. on the water end and 200 lb. on the steam end, so that the pump could be left in service under the maximum pressures of the main pumps without injury. Owing to the leakage on the system being so small, the pump is inconveniently large for the purpose intended, and it has been necessary to keep the delivery by-passed continuously in order to keep the plunger in motion.

63 In order to maintain the air in the delivery air chambers, there are provided two steam driven, crank and flywheel, two-stage air compressors, each having a capacity of 50 cu. ft. of free air per min. against a pressure of 450 lb. There is also provided a wrought steel storage tank 30 in. in diameter by 5 ft. high. There are two large air chambers on the 24-in. discharge mains, in addition to those on the pumps. The former are made of lap-welded rolled steel pipe,

$\frac{1}{2}$ in. thick, 30 in. in diameter and 20 ft. high. The ends are bumped, riveted and welded to the pipe. Two sets of glass gages are attached through bosses welded on the sides.

64 For priming purposes, when lifting from the harbor, there is provided one vertical, steam driven, crank and flywheel single-stage, dry vacuum pump, 6 in. steam, 10 in. air, and 6 in. stroke. This pump is connected to the harbor suctions through a large separator tank at the top of a 40 ft. riser, to prevent water being drawn over into the air cylinder.

65 The plant is provided with a four-motor, electric traveling crane, main hoist 20 tons capacity, auxiliary hoist 5 tons. For lighting the station and for the operation of the electrically driven auxiliaries, there are provided two non-condensing steam turbo-generators.

66 *Tests and Duty Trials.*—The specifications for the pumps provided for an endurance and capacity test of 24 consecutive hours.

67 A normal load duty trial was also specified, covering a period of 12 hours; steam pressure at the throttle 125 lb. The steam consumption was to be based on the feedwater supplied to a separate boiler blanked off from all other sources of supply. The measured consumption was to include all jacket steam, but not that required for boiler feed pumps and other auxiliaries, nor separator condensation and drips from the steam piping on the boiler side of throttle.

68 In order to avoid the insertion of a water meter in either the main suction or discharge lines, a venturi meter is by-passed around a gate valve in the 30-in. city water supply. As the pump discharge can be accurately measured from the record of the pump strokes for a given period, when the slip is known, in this case the venturi meter is only used to calibrate the slip of a single pump, and therefore has a capacity only equal to one pump.

69 The duty specified is 70,000,000 ft-lb. per 1000 lb. of dry steam, under normal operating conditions of 3000 gal. per min. discharge, against a head of 250 lb., with 30 lb. pressure on the suction, and 125 lb. of steam at the throttle.

70 *Boilers.*—The plant is designed for four boilers, each set singly, and each provided with a separate stack carried on structural steel supports directly over the setting. At this time only three boilers have been installed, the fourth will be added in the near future (Fig. 17.)

71 The boilers are of the horizontal, inclined, straight tube type, with forged steel water legs reinforced with hollow staybolts. Each

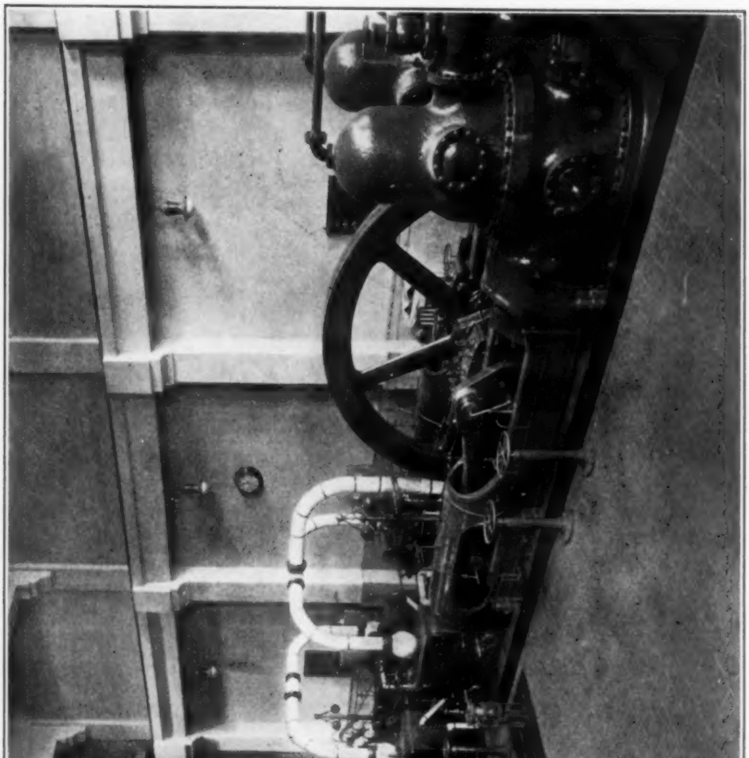


Fig. 15 Interior of Station

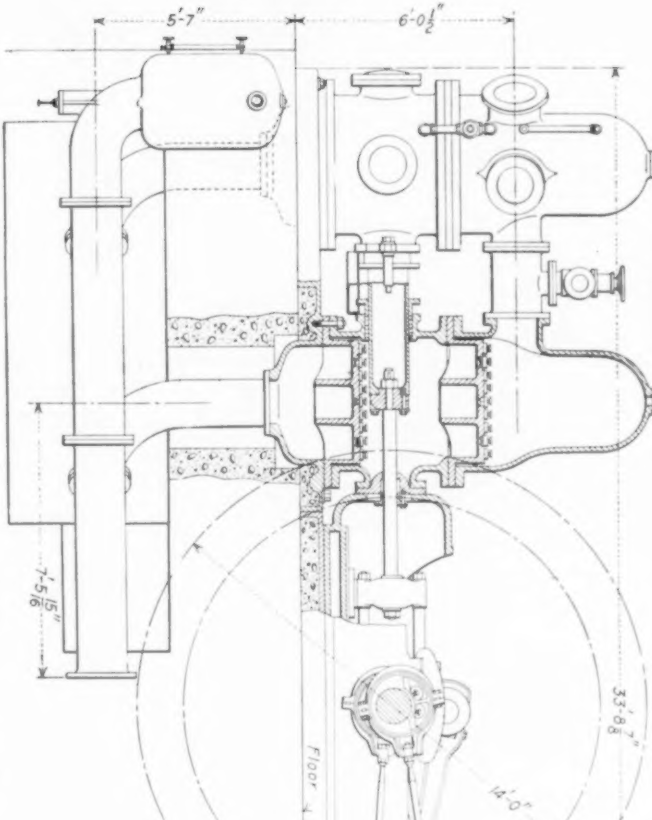


FIG. 16 ELEVATION OF PUMP

boiler contains 6800 sq. ft. of heating surface, and three 36-in. drums. All pressure parts are designed for 200 lb. working pressure. Each boiler is capable of a continuous evaporation of 45,000 lb. of water from and at 212 deg. fahr. into commercially dry steam, when burning semi-bituminous coal of approximately 14,500 B.t.u., with forced draft not exceeding 3 in. of water in the ashpit, or the equivalent of 1 boiler h.p. from 3.77 sq. ft. of heating surface.

72 As the actual time during which the boilers will be in active service will probably average only about 100 hours per annum, the plant was designed for carrying banked fires for a large proportion of the time, with the least possible loss from radiation. The top, sides and rear of each boiler are enclosed in an air-tight steel plate casing. The hotter portions of the side walls, amounting to about 20 per cent of the area of these walls, are covered with 2 in. of magnesia blocks inside the casing. The casing plates are supported on a framework of steel angles, attached to the structural steel members supporting the boilers and stacks. These angles act also as buckstaves for the settings. Access and dusting doors are provided where necessary, which are hinged at the top and close tightly on inclined faces.

73 The boilers are set in the reverse direction from the usual method, that is, with the low end of the tubes over the furnace. The front portion of the furnace is covered with a flat fire brick arch, made of split tiles encircling and supported by the lower row of tubes. When under fire, there is presented to the furnace gases an incandescent firebrick surface, instead of the customary cool iron surface of the tubes. The first pass of the gases between the tubes is at the extreme rear of the boiler, thus providing a furnace area equal to the entire floor space occupied by the boiler inside the setting, and making it possible to force the boiler to 90 per cent over the customary rating without imperfect combustion. A special grade of firebrick was used for the furnace lining, which under a change of temperature of 3100 deg. fahr. shows an expansion or contraction of less than 0.01 in. per ft.

74 *Forced Firing.*—The conditions of fire service require that the boilers shall be capable of changing from banked fires to the maximum capacity in the shortest possible time. The intervals specified were as follows: one-half rated capacity in 5 minutes; full rated capacity in 12 minutes; overload of 75 per cent in 20 minutes.

75 *Choice of Fuel.*—The above conditions made imperative the use of a gaseous fuel, or fuel oil, or forced draft with coal. The

possibility of the use of a combination of two of these was also considered. With gas at 90 cents per 1000 ft., this material was abandoned. The use of crude oil was given careful study. Due to the fact that economy of operating expense was not the primary consideration, the problem was somewhat simplified.

76 As the plant is located in a wholesale district where high values of stock are common, it would have been necessary to have stored the main supply of oil underground. Ample space for this purpose existed in the wide water front street about 200 ft. from the station. On the other hand, experience has demonstrated that oil should be fed to the burners only by gravity from an overhead storage of suitable capacity. Experience has also shown that in spite of all precautions, an oil storage tank will in all probability, sooner or later, take fire. It was of course, possible to design a fireproof barrier which would prevent the fire doing damage to adjoining property. It was believed, however, that in a plant designed for fighting conflagrations, the possibility of an oil fire, with its huge volumes of dense black smoke, would not tend to popularize the system, even if the fire proved to be entirely harmless. In spite of its recognized advantages in ease of handling and quick firing, the use of fuel oil was therefore definitely abandoned, and coal was adopted. The introduction of natural gas from the West Virginia fields has been under consideration for some years, and if this should be accomplished, it would make an admirable fuel for the purpose, either alone or as supplementary to the coal furnaces.

77 *Automatic Mechanical Stokers.*—The use of coal made necessary also the use of forced draft. In addition, it was desirable that during the periods of banked fires, there should be maintained a full bed of ignited coal, requiring only the air blast to force the fire to the highest rate of combustion. The underfeed type of stoker seemed to meet these conditions very satisfactorily. A large body of coal, approximately 1000 lb., can be carried in each furnace, a part of this coal incandescent, a part coked and a part in the process of coking. This represents about 14,500,000 B.t.u. in storage ready for use on a few minutes' notice. As a further heat storage, the steam pressure, which is ordinarily carried at about 150 lb., can be raised to 200 lb., immediately upon the receipt of an alarm. As the normal operating pressure is only from 125 to 150 lb. at the pump throttles, by the time the hose companies can reach the hydrants and attach the hose, and put a sufficient draft on the pumps to pull the steam down to normal, the furnace fires will be ready to respond to any demand.

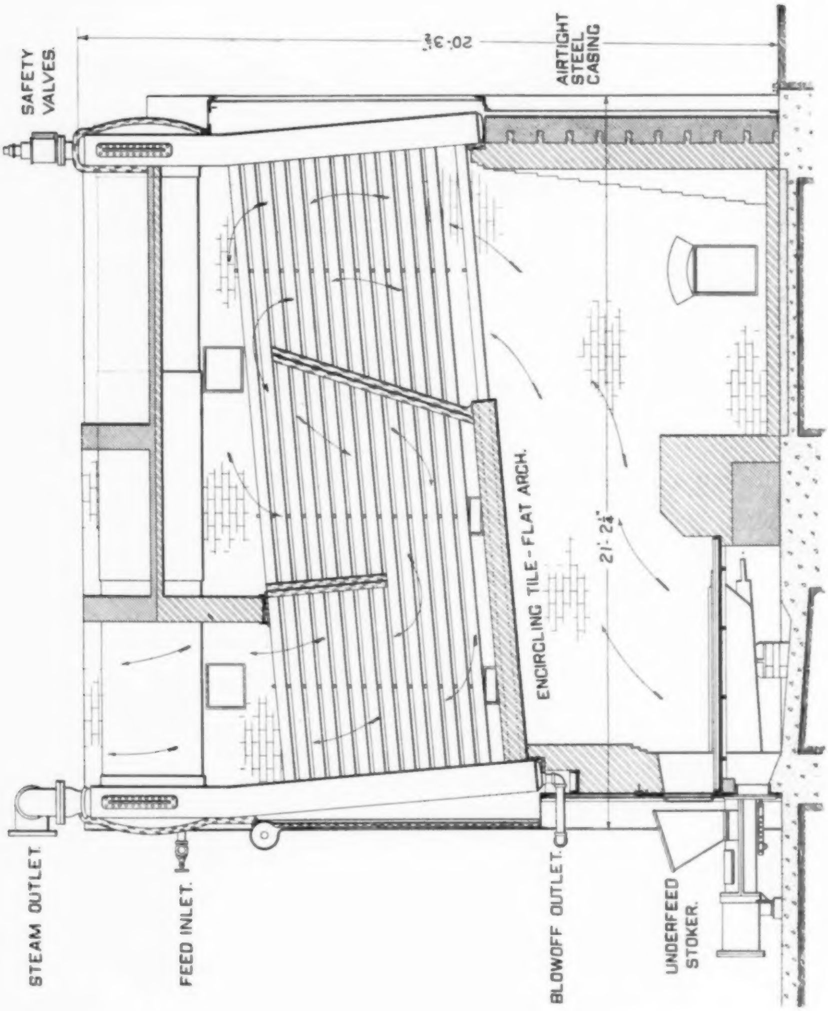


Fig. 17 Section of Boiler

78 Each boiler is equipped with four underfeed stokers, and each stoker unit is capable of burning efficiently, without smoke, 1000 lb. of coal per hour. For the four boilers a duplicate blower equipment is installed, each consisting of a full housed steel plate fan of sufficient capacity to operate the four boilers at 75 per cent overload. Each blower is driven by a direct coupled vertical steam engine. Each blower is connected to the main air pipe line, and by means of dampers either blower can be used to serve any or all the boilers.

79 To regulate the supply of both fuel and air in the proportion required for complete combustion under all rates of firing, the stokers are provided with automatic regulators actuated by the boiler pressure. Provision is also made for hand regulation, so that it is possible to anticipate sudden demands for steam upon receipt of an alarm, and also for decreasing the supply of both fuel and air when the demand for forced firing has passed.

80 *Stacks.*—Each boiler is provided with a separate steel stack located directly over the boiler which it serves. Each stack is 72 in. diameter by 125 ft. above the boiler room floor, and is carried by structural steel framing from the boiler foundations. The stacks are unlined.

81 *Coal Handling and Storage.*—Semi-bituminous run of mine coal is used almost entirely for steaming purposes in the vicinity of Baltimore. In this instance the coal is delivered in carts, the total annual consumption being too small to justify mechanical handling under existing conditions. The coal is dumped on a grating over an opening in the sidewalk, the mesh being 4 in. sq. Large lumps are broken up with a maul, as with the type of stoker in use there is no necessity for the coal to be crushed to smaller sizes. Below the grating there is a dumping hopper which receives the coal and delivers it to the lower run of a bucket elevator. The elevator is a double strand link belt with V-shaped buckets, 16 in. by 15 in., dumping by gravity. The outfit has a capacity of 25 tons per hour with uniform feed.

82 The coal is delivered into reinforced concrete bunkers with inclined bottoms, located directly over the fireroom. The bunkers have a capacity of 150 tons without trimming, or sufficient to operate the entire plant at its maximum capacity for 30 hours. Coal can also be delivered from carts directly on to the boiler room floor, so that the operation of the plant is not dependent upon the coal handling equipment nor the storage supply.

83 *Boiler Feedwater.*—Boiler feedwater is normally supplied

from the city mains under 30 to 50 lb. pressure, sufficient to deliver to the open heaters in the gallery of the engine room, without pumping. In the event of an interruption to the city supply, the feed-water can be taken from a reserve supply stored in steel tanks in the basement under the boilers. For lifting from the storage tanks and delivering to the heaters a duplicate set of low-service duplex steam pumps is provided.

84 To avoid the loss of efficiency in the boilers due to scale, and the necessity for taking the boilers out of service for considerable periods while removing scale, a double unit hot process purifier and heater of the Cochrane type was installed, each half of ample capacity to handle the consumption of the entire plant.

85 The heaters are located in a gallery in the engine room, directly over the boiler feed pumps, thereby providing a gravity head of 25 ft. for the hot water to the pump suction. There are three duplex, outside end packed boiler feed pumps, brass fitted and with pot valves, designed for 300 lb. pressure.

86 In addition to the above, each boiler is provided with a Metropolitan Model O No. 17½ injector, capable of supplying the maximum evaporation of the boiler when lifting from the storage tanks in the basement.

87 Foster excess governors are provided on the feed pumps, and Williams regulators on the boilers.

88 *Piping.*—A 12-in. steam header forms a closed ring around the plant, with long radius expansion bends at all changes in direction (Figs. 18, 19, 20). A sufficient number of gate valves are placed in the header to sectionalize it, so that any portion may be cut out without disabling more than one boiler or one pump. Pipe is full weight, lap welded, soft open hearth steel. To provide an independent header for the station auxiliaries, a 6-in. cross connection is made across the center of the main header, which is capable of being fed from either side of the main header, in case of accident to the other. No fittings whatever are used in the main line, all branches being taken from interlocked welded necks. Boiler branches are provided with non-return valves at the boiler nozzles and gates at the header end. Van Stone flanges are provided for connections to the valves and receivers, which are located so as to avoid as far as possible the necessity for any additional joints in the line. Wrought steel receiver type separators are installed at the low points on each side of the header.

89 The exhaust system is extremely simple, a multi-port back

pressure valve on the 18-in. riser serves to turn all the exhaust into the heaters at light loads, and provides a direct path to the atmosphere when the steam is in excess of the heater requirements.

90 *Building.*—The site of the pumping station is a lot 69 ft. front by 137 ft. deep, running back to a 16 ft. alley. The property immediately adjoining on the two sides is occupied by warehouses carrying more or less inflammable stocks. On the opposite side of the alley the same conditions exist. All foundations for the pumping station and machinery were designed to rest on caissons carried to the gravel, so that it was necessary to underpin the walls of both the adjoining buildings.

91 All structural portions of the building, including columns, girders, beams, floor and roof slabs, and all walls except the front, are of reinforced concrete. The adjoining buildings on the sides are from 10 to 20 ft. higher than the station roof, so the roof girders, beams and slabs were designed to withstand the shock of falling walls in case of fire. The side walls are not less than 8 in. thick in any part, and have no openings whatever. The rear wall is the same, except that there is one door at the level of the boiler room floor.

92 For access to the men's quarters an automatic push-button electric elevator is installed, in addition to the stairway. Standard brass sliding poles are also provided for quick response to an alarm. The quarters are located over the front of the engine room, and include a dormitory, dressing room, bath, toilet and reading rooms. In addition, a private bedroom, bath, parlor and office are provided for the chief engineer.

93 In addition to the fireproof construction of the building, further fire fighting equipment for the protection of the station consists of a water curtain for the exposed front and rear, and two 8-in. standpipes, to be fitted with monitor nozzles. A dangerous fire in the immediate vicinity of the station could thus be effectively fought from the roof as well as from the ground.

94 *Signaling System.*—In addition to the regular fire alarm circuit, a separate telephone circuit runs to the pumping station from fire alarm headquarters, fire department headquarters, and the chief's night quarters. This circuit connects to contacts for portable telephones in each fire-alarm box in the high-pressure district. In addition to the regular Morse key and sounder there are contacts for a telephone connection in each box, over the fire alarm circuit. Finally there is available the regular public telephone service.

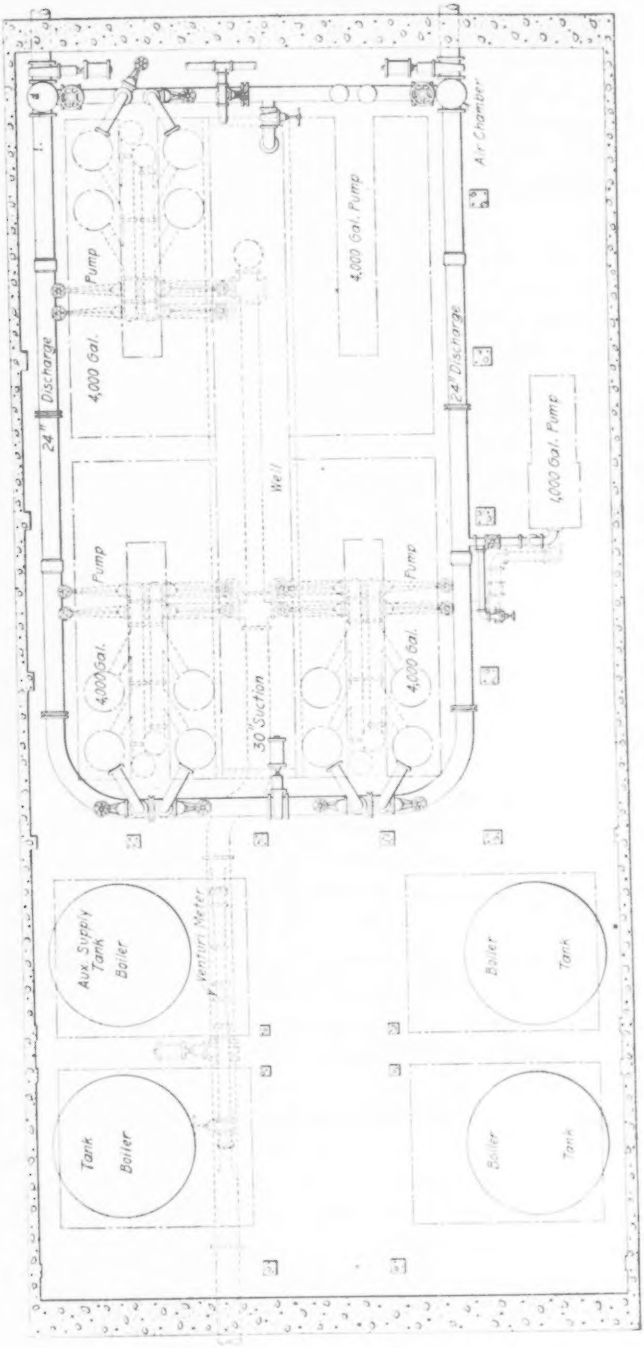


FIG. 18 PLAN OF STATION, SHOWING WATER PIPING

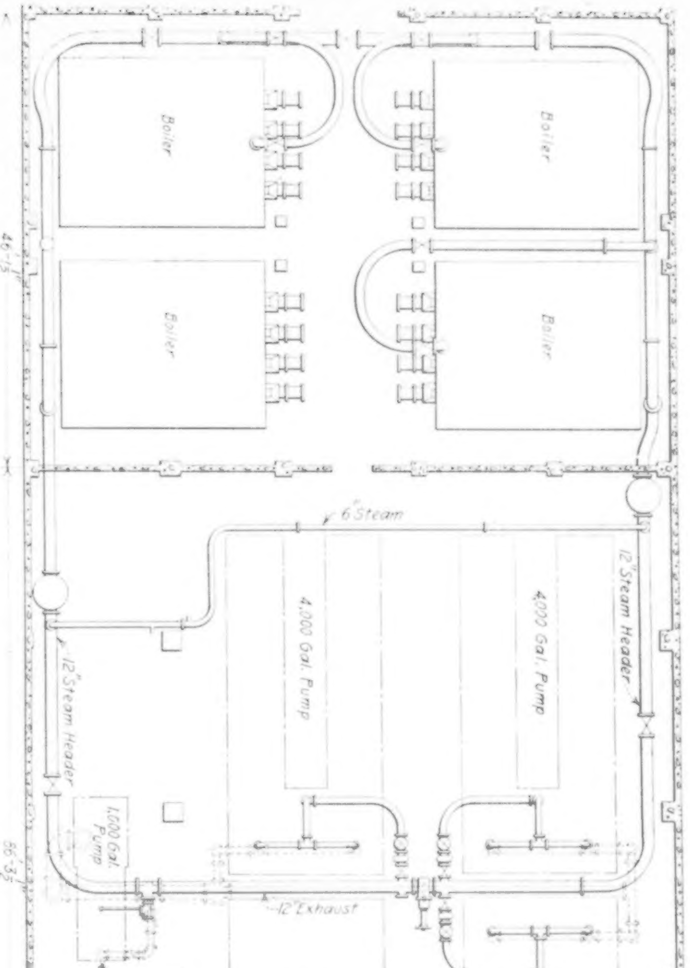


FIG. 19 PLAN OF STATION, SHOWING STEAM PIPING

CONSTRUCTION COSTS

Portable Equipment			
2 automobile hose wagons at $5000		$10,000	
8000 ft. 3 in. hose at $1		8,000	
30 portable heads and regulators at $385		11,550	
Total		$29,550	
Pipe System			
Material delivered Baltimore			
Hydrants, 226 at $100	$22,600		
8 in. pipe, 7137 ft. at $2.35	16,700		
10 in. pipe, 28,229 ft. at $3.10	87,700		
16 in. pipe, 17,052 ft. at $5.25	89,600		
24 in. pipe, 1275 ft. at $10	12,750		
8 in. gate valves, 6 at $100	600		
10 in. gate valves, 193 at $130	25,000		
16 in. gate valves, 90 at $210	18,900		
18 in. gate valves, 2 at $300	600		
24 in. gate valves, 3 at $1,000	3,000		
Air and relief valves	200		
Low pressure gates, 2–30 in.	500		
Suction pipe, 400 ft. cast iron, 30 in., at $4	1,600		
Steel air chambers, 2–30 in., at $500	1,000		
Venturi meter	500		
Cast steel specials	17,500		
		$298,750	
Installation			
Laying pipe, including placing valves, fittings, hydrants, etc.			
8 in. pipe, 7,137 ft. at $0.70	$4,996		
10 in. pipe, 28,229 ft. at 0.75	21,200		
16 in. pipe, 17,052 ft. at 1.15	19,600		
24 in. pipe, 1,275 ft. at 1.75	2,230		
Pump connections in station	6,000		
Laying 30 in. c. i. suction	3,400		
Tapping 40 in. main	1,500		
Concrete valve boxes, 293 at $30	8,790		
Excavation, back filling and rubble paving			
41,318 ft. open trench, at $3.84	158,600		
12,375 ft. tunnel, at $4.08	50,400		
Improved paving, 6650 sq. yd., at $1.50	10,000		
Superintendence, use of tools, etc.	50,000		
		$336,716	
			$635,466
Pumping Station			
Site and preliminary work		$37,730	

Building, including machinery foundations, and men's quar-

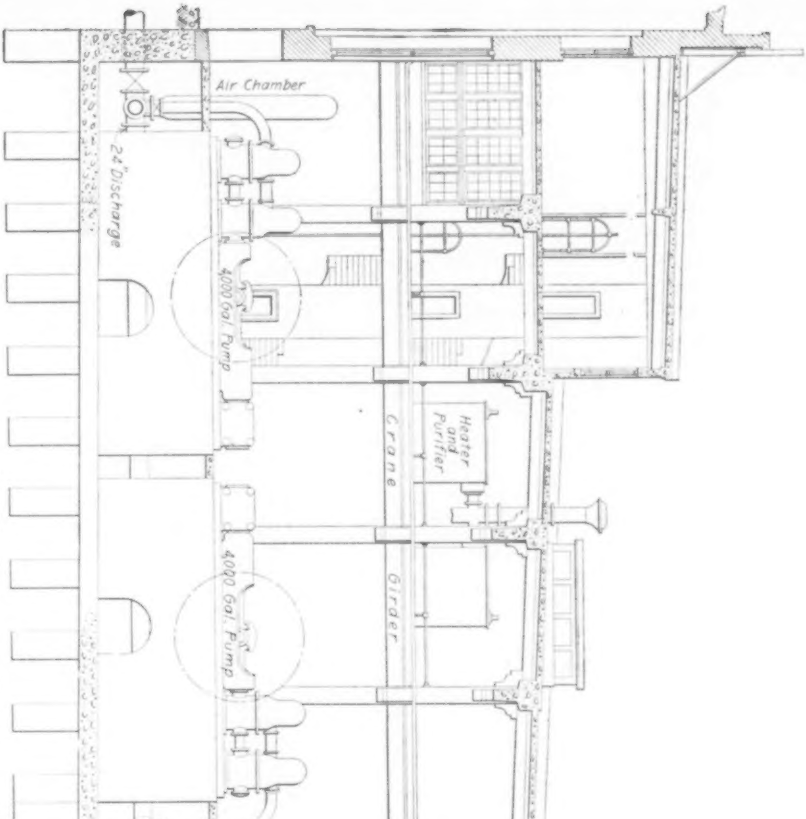


FIG. 20 SECTIONAL ELEVATION OF STATION

ters		124,800	
Harbor intake and screen chamber		10,000	
Equipment			
Four 4000 gal. pumps	$82,000		
One 1000 gal. pump	3,500		
Auxiliary pumps	4,250		
Feedwater heaters and purifiers	4,750		
4 boilers and settings, 27,200 sq. ft. heating surface	33,000		
16 underfeed stokers, blowers, air piping, etc.	18,000		
4 steel stacks and supports	8,000		
Coal handling apparatus	7,000		
Turbo-generators and switchboard	4,500		
Electric crane	4,000		
Steam and auxiliary water piping	30,000		
		$199,000	
			371,530
Miscellaneous			
Signal system, cables, etc.	$1,500		
Furnishings for men's quarters	500		
Incidentals	5,000		
			7,000
Engineering			50,000
Total cost of construction			$1,093,546

95 *Operating Department.*—The Board of Fire Commissioners is the executive head of the operating department, acting through the department chief. The operation and maintenance of the pumping station and the maintenance of the pipe lines, hydrants and portable heads are directly under the supervision of the department superintendent of machinery, Thomas H. Meushaw. The maintenance work for the pipe line is in charge of a general foreman, John Rudolph, who was chief inspector for the city during the early part of the installation, and general foreman for the contractor during the latter portion of the work.

96 The operating force at the pumping station is in charge of a resident engineer and five assistant engineers, with four stokers and two general assistants, all organized as a fire company. Two additional stokers have been recommended by the superintendent of machinery, and will probably be added in the near future, making a total station operating force of fourteen men. Of these an engineer and stoker are on active duty at all times, with a four-hour watch.

Immediately upon the receipt of an alarm all hands report on the operating floor. As a pressure of 150 lb. is maintained during the standby period, orders have been issued that in the event of the pumps automatically speeding up without an alarm, the plant shall be shut down immediately. This course is taken to avoid water damage, should a break occur. Up to this time no occasion has arisen to require the execution of this order, however.

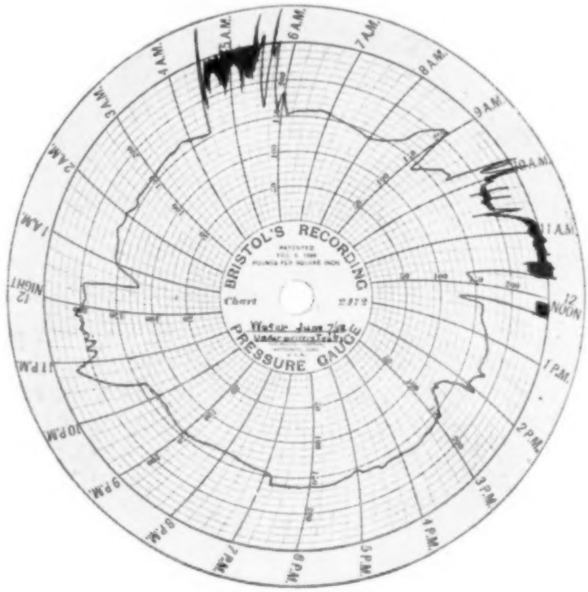


FIG. 21 CURVE OF WATER PRESSURE DURING UNDERWRITERS' TESTS

TESTS

97 *Opening Demonstration.*—The system was formally placed in operation on May 20, 1912, with a public demonstration on the Court House Plaza. At first twenty-four $1\frac{3}{4}$-in. streams were used from single hose lines held by tripods. Later seven $2\frac{1}{2}$-in. streams were thrown, from monitor nozzles on the wagons. About 13,000 gal. per min. were delivered.

98 *Underwriters Tests.*—A readiness test was made June 7, readings being taken by a stop-watch.

4.30.00 a.m. Fire alarm box pulled; one engineer and one stoker on duty at station.

4.31.00 a.m. Chief engineer with four additional engineers

and three additional stokers had responded from sleeping quarters.

4.31.15 a.m. Two large pumps started up, pressure increased from 150 to 190 lb.

4.33.00 a.m. Pressure 280 lb. Hose company turned water on to two 3-in. hose lines siamesed into one $2\frac{1}{2}$-in. monitor nozzle.

4.34.00 a.m. Discharge was 1050 gal. per min.

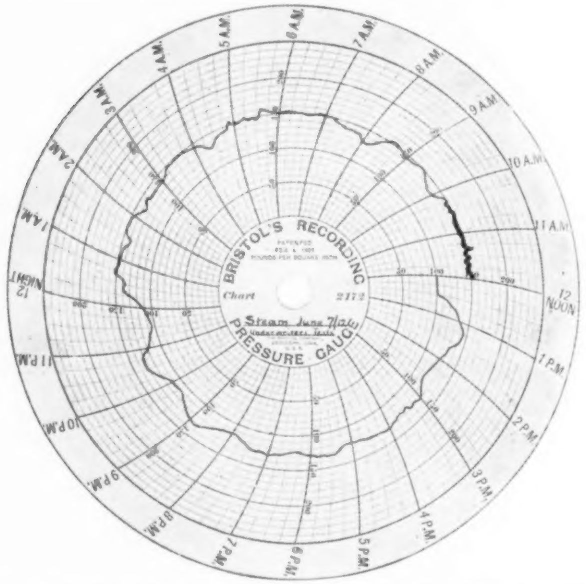


FIG. 22 CURVE OF STEAM PRESSURE DURING UNDERWRITERS' TESTS

4.37.40 a.m. Two additional $2\frac{1}{2}$-in. nozzles in service, total discharge 4000 gal. per min.

99 A second company was then ordered into service at another point, with three $2\frac{1}{2}$-in. nozzles, bringing the total discharge up to 7100 gal. per min. See water and steam charts from Bristol gage at station (Figs. 21 and 22).

100 A general performance test was made June 7, from 9.45 to 10.15 a.m. (see Bristol charts). Pumps were started and stopped, and hydrants were opened and closed as rapidly as possible to test the ability of the pumps and governors to take care of abnormal operating conditions.

101 Individual pump tests were made the same date, from 10.15 to 10.45 a.m., with the following results:

Steam at throttle, lb.	146
Water pressure, discharge, lb.	199
Water pressure, injection, lb.	41
Water pressure, net, lb.	158
Revolutions per minute	55
Discharge, gal. per min.	4592

102 A general capacity test was made 10.45 to 11.40 a.m., with the following results (three pumps in service):

Steam at throttle (average), lb.	145
Water, discharge, lb.	240
Water, injection	?
Water, net	?
Discharge, gal. per min.	12,770

103 During the latter test six $2\frac{1}{2}$-in. nozzles and six 2-in. nozzles were in use, discharging into the harbor (see Fig. 23).

RESULTS OF OPERATION

104 The department chief is enthusiastic over the efficiency of the entire system as a modern fire fighting equipment. He makes the statement that during the two months which it has been in operation, three bad incipient fires have been literally "drowned out" by the system. The probable losses from these fires, under former conditions, would more than have equalled the entire cost of the high-pressure service. By the time the department arrived on the scene at one fire, the smoke was so dense that from the middle of the street it was impossible to locate any window or door openings in the building. Three $2\frac{1}{2}$-in. monitor streams were blindly turned on the building. The water reached the fire, but not through windows or doors. When the smoke had cleared away, three holes were discovered in the 18-in. brick walls, bored straight through the masonry by the high-pressure streams.

105 The engineers of the National Board of Fire Underwriters, after a thorough test and a special search for weak points, reported as follows:

The distributing system has been installed for two years and shows no signs of deterioration. The slight leakage, absence of electrolytic action and total freedom from breaks or other troubles appear to justify the departure from the usual design of such systems. . . . The valve and hydrant distribution is excellent, and the pipe sizes and gridironing are sufficient to enable a good concentration of flow without serious loss of pressure. . . . The separate hydrant head permits the use of regulator valves permanently attached, giving excellent control of the pressure on hose lines. The hydrant head under test showed sufficiently low friction loss. . . . The operation of the pumping plant is prompt and reliable.

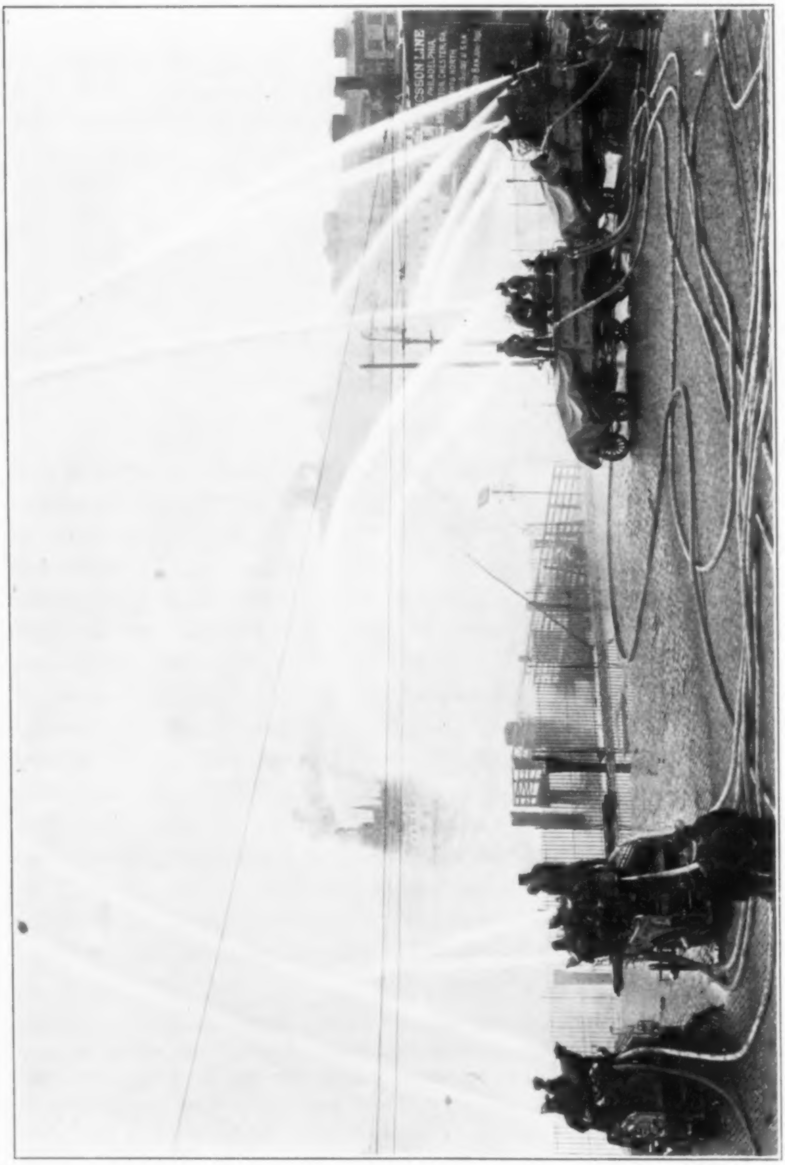


FIG. 23 VIEW OF STREAMS DURING UNDERWRITERS' TESTS

106 As a result of the installation of the high-pressure system, the underwriters have announced a rebate of 5 cents in the insurance rate on all property in the district covered. While no exact summary has been made of the aggregate saving which will result from this reduction, it is roughly estimated that the amount will be approximately $40,000 per annum, which will be increased almost in direct proportion with the extension of the mains.

ORGANIZATION

Construction.—The executive head of the project is the Board of Fire Commissioners. To act with the chief of the department the board appointed a consulting engineer, D. B. Banks, who in collaboration with the writer, designed the system. After the general plans had been drawn, but before the construction had been begun, the board employed two additional consulting engineers to pass upon the general features of the design. R. C. Carpenter and Frederick H. Wagner, chief engineer of Bartlett & Hayward Company, Baltimore, were chosen, and after a careful study these engineers approved the general plans and the details as far as completed. The architectural features of the station were designed by Henry Brauns, the veteran power plant architect of Baltimore. General supervision of the construction was exercised by Wm. McCallister, Jr., assistant to the consulting engineer. Before the construction work was completed, the department chief, George W. Horton, was retired, and the deputy chief, August Emerich, was promoted to the head of the department.

Contracts for the various elements of the system were awarded to the following builders and contractors:

Automobile hose wagons to the Mack Mfg. Co.

The portable hydrant heads and regulators, and the main pump governors to the Ross Valve Mfg. Co., of Troy, N. Y.

The hydrants and high pressure water pipe lines to the Pittsburgh Valve Foundry & Construction Co., of Pittsburgh. Many of the working details of the system were designed by J. Roy Tanner, chief engineer, and Charles Fitzgerald, superintendent of construction for the contractor. A subcontract for the supervision of the trenching was awarded by the general pipe contractor to E. Saxton, of Washington, D. C., one of the most experienced contractors in the vicinity on subsurface structures in city streets.

Pumps to the Allis-Chalmers Co., of Milwaukee, although this concern was not the lowest bidder. A subcontract for the 1000-gal. direct acting pump and the boiler feed pumps was awarded to the Epping Carpenter Co. of Pittsburgh.

Boilers to the Edge Moor Iron Co. of Wilmington, Del. A subcontract for the stokers, blowers and regulators was awarded to the Underfeed Stoker Company of America, Chicago.

The steam and auxiliary water piping in the pumping station to the Crook-Kries Co., of Baltimore.

The station building and harbor intake to the B. F. Bennet Bldg. Co. of Baltimore.

The signal system was installed by the department force.

NATIONAL STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE

By F. M. Griswold

ABSTRACT OF PAPER

The paper calls attention to the enormous waste by fire each year in this country and refers to the frequent occurrence of conflagrations in various localities where the assistance called for from neighboring communities has often proved of little value on account of the lack of uniformity in fire-fighting appliances. The author makes an appeal for the early adoption and use of a practical standard coupling for public fire service use.

Specifications are given of the National Standard Hose Couplings, and several important public bodies and organizations cited which have approved this standard. Various localities are named where couplings, ranging in diameter from 3 1/32 in. to 3 5/64 in. and having 7, 7½ or 8 threads to the inch have been readily and cheaply modified to couple-up with the standard sizes by the use of a standard female ring or swivel having inside diameter of 3 1/16 in. with 7½ threads to the inch.

The paper explains the method of procedure for the conversion of couplings of various dimensions to interchange with the standard, and cites the methods actually used in several instances by the public authorities, giving data and costs.

Attention is urged to the importance and necessity of early action to secure standardization of this essential utility in use in combatting fire in public service.

NATIONAL STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE

By F. M. Griswold,[1] New York

Non-Member

The created resources of this country are depleted annually to the enormous extent of about $250,000,000 through destruction by fire, 80 per cent of which can be justifiably attributed to preventable causes.

2 This vast fire waste serves to remove completely from the acquired assets of our people at large and from the wealth of the nation, the enormous sum of $685,000 for each day of the year, while for each minute of the day, $500 in tangible values rises in flame and smoke as a burnt offering to a veritable Moloch of recklessness, leaving only an ash-pile as its monument; thus placing a yearly burden of indirect and unjustifiable taxation at the rate of $2.65 per capita upon our 95,000,000 of population, which, if collected under process of law, would doubtless incite to vigorous public protest.

3 While a large proportion of these losses follow from what may be termed "individual burnings," where the fire may have been held within the structure in which it originated, yet by far the larger proportion is due to the spreading fires, which, getting away from the control of the local fire department, result in conflagrations of greater or lesser magnitude, and quite frequently reach such proportions as to necessitate calls for assistance from neighboring and sometimes from distant communities, in the effort to check the spread of flame which has passed beyond local control. In such cases, however, experience proves, almost without exception, that when the foreign apparatus arrives upon the scene it will not interchange with that already

[1] Genl. Inspr., The Home Insurance Co., 56 Cedar St.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

in use in some minor, but vital particular, and under these conditions, flame spreads unchecked so long as fuel to feed combustion remains in its path. Hundreds of thousands of dollars in value and many human lives are thus sacrificed as a consequence of inexcusable neglect in the standardization throughout this country of public fire-fighting utilities.

4 In corroboration of this statement may be recalled some of the notable conflagrations which have occurred within the memory of the man of middle age: Chicago, 1871; Boston, 1872; Baltimore, Rochester and Ottawa, Canada, 1904; Chelsea, Mass., 1908. In each of these instances and in hundreds of others where conflagrations of lesser magnitude have occurred, it became necessary to call for aid from the fire departments of other cities, and in each case the proffered assistance proved of little value, because of some difference in the diameter, or of the pitch or shape of the thread on hose couplings or hydrant outlets rendering them non-interchangeable with the local utilities of like character. These chaotic conditions are broadly exemplified by our records of couplings for 2½-in. hose, which show differences ranging from 2 in. in diameter with tapered iron pipe thread of 11 turns to the inch, followed by increases of diameter progressing at the rate of 1/64 in. up to 2 5/8 in., with threads varying from 6 to 9 per inch; in addition to these vagaries in threaded couplings, there are to be found several kinds of "snap" or other special or novel devices used as couplings in some localities.

5 In view of these conditions and of the too frequently demonstrated fact that the average public fire department is not so fully equipped as to enable it alone to cope successfully with a fire of conflagration proportions, and will therefore doubtless be compelled in the future, as in the past, to call upon other communities for aid in times of such emergency, it appears to be exigent that an officially recognized standard of uniformity in fire-fighting appliances and utilities should exist in every town and city of this country, especially in relation to the diameters and other particulars of hose couplings and hydrant outlets, which constitute the absolute essentials both in the means and method of conveying water in fire extinguishment.

6 It is this inexcusable lack of uniformity of these simple but vital public fire-fighting utilities that prompts the writer in the dual capacity of a member of the Sub-Committee on Fire Protection of this Society and as chairman of a special committee

on hose couplings and hydrant fittings of the National Fire Protection Association, to present an appeal for approval of the National Standard Hose Couplings and Hydrant Fittings for Public Fire Service, which have already been approved and adopted by the following important public bodies and organizations controlling or supervising the design, installation and use of such public utilities, after having been agreed upon in joint conference with their accredited representatives:

American Public Works Association
American Society of Municipal Improvements
American Waterworks Association
International Association of Fire Engineers
League of American Municipalities
Minnesota State Fireman's Association
National Board of Fire Underwriters
National Fire Protection Association
National Firemen's Association
New England Waterworks Association
North Carolina State Firemen's Association
Pennsylvania Waterworks Association
Virginia State Firemen's Association

7 It is remarkable that in this age of advancement, when every faculty of the practical man engaged in the mechanic arts is centered upon securing uniformity in practice as to the design and proportions of the various devices and appliances in general use in the field of his endeavor, that so important and universally necessary a public utility should have been permitted to escape the influence of this spirit of progress, and remain to this day a matter subject to the caprice or ignorance of those responsible for the specification and installation of such important adjuncts in public fire protection.

8 The first concerted attempt to secure the adoption of a standard hose coupling dates from the organization meeting of the National Convention of Fire Engineers, held in Baltimore, Md., October 1873, when, with the lessons before them of the great Chicago fire of 1871, and of the conflagration of 1872 in Boston, this assemblage of fire chiefs from all sections of the country, gave expression to their desire to have adopted a standard hose coupling which would serve for general use, in a resolution offered by Chief Hill, of the Cleveland, Ohio, department, to the following effect:

Whereas, experience has shown that the fire departments of the country should be provided with a universal or standard coupling for hose and fire hydrants, so that when a city or town calls for aid, in case of large fires or conflagrations, from another city or town, that each department can act in unison with the other;

Therefore be it resolved that a committee be appointed by this convention to take under consideration, and report back to this Convention the practicability

of adopting a standard coupling of some kind to be used by all fire departments throughout the United States.

9 In forwarding this resolution its proposer expressed the desire to have adopted a standard of such character, "that a line of hose might be laid from coast to coast with couplings which would permit any town on the line to tap-in." While the printed record of this convention does not give exact details of the dimensions of the standard then proposed, contemporary documents establish it as being $2\frac{1}{2}$ in. inside diameter, 3 1/6 in. outside diameter over thread of male end, with $7\frac{1}{2}$ threads to the inch. Accepting this standard as official, some of the chiefs upon returning to their home towns, changed their couplings to conform to these dimensions and have since maintained this standard in operation.

10 Outside of the instances noted, the matter of standardization failed of immediate accomplishment owing to the fact that no concerted and continued action was undertaken by this body of fire engineers to keep the proposition alive, who seemed content to let the resolution appear in the printed proceedings of the convention as closing the incident.

11 The matter came up again, however, at the convention of this organization in 1875, when there was adopted as its standard a coupling of $2\frac{5}{8}$ in. inside diameter, by $3\frac{1}{8}$ in. outside diameter, *exclusive of the thread* and of $3\frac{3}{8}$ in. outside diameter *inclusive of the thread*, the latter to be 8 to the inch; in the 1876 convention this standard was reaffirmed, but in the convention of 1878 a special committee reported that the 1875 specifications were found to be impracticable in use, and here again the matter rested, no new specifications at that time being presented to the convention.

12 Again in 1879 the firemen submitted as their standard a coupling of $2\frac{1}{2}$ in. inside and 3 7/32 in. outside diameter, with 6 V-shaped threads to the inch, which was duly adopted, but the matter lay dormant until the convention of 1883 when the 1879 specification was endorsed and resolutions were passed to secure coöperation through state legislation, and while some sporadic effort seems to have been made toward this end, nothing was accomplished which held promise of success, and the matter of legislation appears to have been dropped entirely.

13 For the period between 1883 and 1890 the question of standardization also appears to have rested, but in the latter

year renewed interest was aroused in the subject through the reading of a paper before the Firemen's Convention at Detroit, Mich., by C. A. Landy, the substance of which was based upon a letter written by John R. Freeman. A strong plea was made by him for the adoption of "a single standard thread for $2\frac{1}{2}$-in. couplings, which should be universal throughout the United States." At the suggestion of Mr. Freeman, a special committee was appointed to investigate prevailing conditions as to couplings in general use, and to formulate specifications for the proposed standard.

14 At the convention held at Springfield, Mass., in 1891, the special committee made report through the chairman, C. A. Landy, showing very complete data relating to $2\frac{1}{2}$ in. screw-couplings, found to be used in 1339 towns and cities of this country, showing outside diameter over thread of male end ranging from 3 in. to $3\frac{1}{8}$ in. and including threads of 7, $7\frac{1}{2}$ and 8 to the inch, and strongly advocated the adoption as a standard for $2\frac{1}{2}$ in. hose, a coupling showing 3 1/16 in. diameter over threaded male end, with $7\frac{1}{2}$ threads to the inch, as being an intermediary of such range and value as to insure progressive standardization at the least expense and trouble in the conversion of non-standard to serviceable interchange with it, the feasibility of such interchange being demonstrated by the use of a female swivel of 3 1/16 in. diameter with $7\frac{1}{2}$ threads to the inch, into which male ends of both 7 and 8 threads to the inch were entered and formed serviceable connections; about 70 per cent of the couplings listed in Landy's report being susceptible to such adaptation.

15 The demonstrated feasibility of adapting these non-standard couplings to interchange in service with the proposed standard carried conviction to the members of the convention, and the recommendations of the special committee were adopted, including specifications for larger sized hose up to 6 in. in diameter, each of such sizes in excess of $2\frac{1}{2}$ in. nominating 8 threads to the inch.

16 A resolution to print these specifications in the Proceedings served again to close the incident, and thus the solution of the hose coupling problem was permitted to rest undisturbed for a period of 13 years, or until 1904, when the great conflagration at Baltimore not only demonstrated the limits of local equipment in controlling an extending fire, but also served to bring attention to the folly of permitting continuance of those chaotic con-

ditions in relation to fire department appliances, the existence of which rendered practically ineffective the men and apparatus sent from other cities to aid Baltimore in the hour of its extremity.

17 Confronted with this record of 31 years of failure to secure the adoption and use of a practical standard hose coupling, it became evident that if success was to be the reward of further effort in this work, it could only be won through earnest and persistent coöperation between the leading organizations or other interests controlling the production of, or being responsible for the purchase, installation and upkeep of these highly important public fire-fighting facilities, and with a hope of being able to arouse general interest in this method of procedure, the National Fire Protection Association selected the writer as its delegate to the convention of the International Association of Fire Engineers held at Chattanooga, in September 1904, instructing him to propose joint action by these two organizations in a renewal of the effort to devise an acceptable and practical national standard hose coupling.

18 In consideration of the problem thus presented, it became a question whether to advise the adoption of a hose coupling thread, the specifications of which would show the extreme of mechanical strength without reference to the preponderance of designs of a less theoretical value then in general use, or to seek for the introduction of a threaded coupling the characteristics of which would most closely accord with the majority class, and at the same time prove to be an intermediary of such capacity as to accommodate itself to interchange with a large proportion of couplings not exactly conforming to its dimensions.

19 Accepting the latter method of procedure as promising the widest measure of success, the committee of the National Fire Protection Association undertook a special investigation of existing conditions, using the Landy report of 1891 as a basis, and after securing such additional data and being convinced of the practical value of the specifications named in that report, submitted as a standard coupling for 2½ in. hose, one showing a diameter of 3 1/16 in. over male and thread with 7½ threads to the inch, by the use of which it was practically demonstrated that couplings ranging in outside diameter from 3 1/32 in. to 3 5/64 in., with either 7, 7½ or 8 threads to the inch, could be so modified as to couple-up in service with this suggested stan-

dard, and thus render over 70 per cent of the 2½-in. couplings known to be in use, conformable to the proposed standard at small expense as to time, money or labor.

20 In elucidation of the essential features of this standard it was deemed wise to formulate specifications covering 2½, 3, 3½ and 4½-in. hose couplings, the inside diameters of which were to be in conformity with the sizes named, specific details relating to each of the standard sizes being shown in the printed specifications as follows:

Inside diameter of hose, in.	2½	3	3½	4½
Number of threads per in.	7½	6	6	4
Male Couplings				
Outside diameter of thread finished, in.	$3\frac{1}{16}$	3⅝	4¼	5¾
Diameter at root of thread, in.	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads, in.	0.03	0.03	0.03	0.05
Total length of threaded male end, in.	1	1⅛	1⅛	1⅜

The above were to be of the 60-deg. V-thread pattern with 0.01 in. cut off the top of thread and 0.01 in. left in the bottom of the valley in 2½-in., 3-in. and 3½-in. couplings, and 0.02 in. in like manner for the 4½-in. couplings and with ¼-in. blank end on male part of coupling in each case. Female ends were to be cut ⅛ in. shorter for endwise clearance. They should also be bored out 0.03 in. larger in the 2½ in., 3 in. and 3½ in. sizes, and 0.05 in. larger in the 4½ in. size in order to make up easily and without jamming or sticking.

21 The printed specifications for the national standard coupling include full sized working drawings showing the details of the various dimensions above noted, and in addition contain matter descriptive of the method of procedure for converting non-standard couplings to interchange with the national standard in service, and also cover the matter of standard fire hydrant fittings. Copies of these specifications may be had upon request.

22 It may be well to explain that 2½-in. hose is the size in most general use by public fire departments for their leading lines; and it is in this size of hose that the most marked diversity in the character and dimensions of couplings is to be found; the 3 in. and the 3½ in. sizes being mainly used for high-pressure or fire-boat service, are not in such general use, but the specifica-

tion for six threads on couplings for this service conforms to general practice in relation to these sizes. The dimensions specified for the $4\frac{1}{2}$-in. engine suction hose are necessary to conform to the capacity requirements of the standard fire hydrant, which shows a 6-in. barrel fed through a six-branch line from the street main. The nomination of four threads to the inch on the suction hose is in conformity with the general practice of fire engine builders, and is known to the trade as the "Amoskeag thread."

23 Having come to this decision, the committee, bearing in mind the failure of past efforts because of the lack of coöperation between the interests vitally concerned, sought the advice and coöperation of organizations having control or supervision of the installation of these public utilities. To that end the matter was taken up with the several organizations already mentioned as having adopted the standard, and the details of specification as above presented were critically considered and accepted by each without change, as being of such practical utility as to warrant the general adoption of the National Standard Hose Coupling.

24 When this proposition was first presented for acceptance, the committee which the writer represents held data relating to coupling dimensions in about 1600 separate localities in this country, but since that time it has created a card index record containing data from some 3133 towns and cities in the United States and the Dominion of Canada. This record is believed to be as nearly accurate as can be expected in a work of this character and magnitude. The data were carefully compiled from ten separate sources of information, including signed statements from fire chiefs and waterworks managers, transcripts from the tabulated record of coupling dimensions prepared by John R. Freeman in 1892, and from official records of many manufacturers of hydrants, hose or other fire department apparatus, supplemented by reports of the engineers employed by the various insurance inspection organizations.

25 Analysis of the data shown in this record, based upon actual results accomplished in the conversion of non-standard couplings safely to interchange with the established standard, demonstrates that approximately 80 per cent of the couplings listed are either of standard dimensions or may readily be modified so as to conform to them, without necessity for replacement,

while the cost of conversion or replacement has been practically demonstrated to be so small as to be almost negligible in the accomplishment of this very essential change from chaos to uniformity in public fire-fighting utilities.

26 In evidence of progress in this work, the record shows 73 cities or towns in which the national standard has been put into service, either as new equipment, or by adaptation of non-standard couplings to interchange with the standard, while seven installations include the complete substitution of national standard hose couplings and hydrant nipples in place of previously prevailing non-standard devices, under such conditions as to methods of procedure and cost of substitution warranting brief mention. Notable among these are the city of St. Louis, Mo., the pioneer in the active promotion of standardization, where over 11,000 hydrant outlets and the couplings on many thousands of feet of fire hose were changed from a so-called "bastard" six thread to the standard, all of the work being done by city employes, at an average net cost of $1 per hose coupling, and of $2.82 per hydrant outlet, the latter being principally of $4\frac{1}{2}$-in. steamer suction type, each of which was laboriously chipped-out by use of a cold-chisel.

27 Closely following this action by St. Louis, the city of East St. Louis which lies on the opposite shore of the river in Illinois, brought its equipment into conformity with that of the larger city upon which it must call for aid in time of threatening disaster.

28 During the winter of 1910-1911, the city of Springfield, Mass., discarded the "universal clutch" coupling and substituted for it the national standard, changing 1350 hydrants, some of which had four outlets, at the rate of from 50 to 100 outlet replacements per day, at an average net cost of $1 per outlet, giving credit for the old metal, sold at $9\frac{1}{2}$ cents per lb., and excluding cost of labor performed by the regular force of water-works employes. Couplings on 22,000 ft. of hose were changed by department employes at a like net cost of $1 each.

29 It is interesting to note that this work at Springfield was carried out in the winter season, and that it was accomplished without accident by the use of surprisingly simple and expeditious methods, in that, where hydrant nipples were leaded-in, the use of a 6-lb. sledge proved an efficient means for their removal, while in the case of screwed-in nipples, an expanding

wrench, entered from the out-board end of the nipples engaged the operating lugs and permitted the easy removal of the device, while the 4½-in. leaded-in suction nipples were melted out by the use of a plumber's gasolene blow torch, at the rate of 5 min. per operation. This practical and unique demonstration of "how to do it" is commended as being worthy of serious consideration.

30 Following this action at Springfield, the contiguous cities of Chicopee, Holyoke and West Springfield, each brought their equipment into conformity with the standard, at an expense probably no greater than was that of the change at Springfield.

31 Shreveport, La., replaced the old-time "Feyh" coupling by installing the standard, but there are no data as to method of procedure, nor as to the cost of the operation.

32 In the cases of many other towns and cities which are known to have adapted non-standard couplings to interchange with the standard, the work has been accomplished entirely by the regular force of public employes, and outside of the time used the expense has been nominal, at most involving the cost of an adjustable tap and die, conforming to the pitch of the non-standard thread, by the use of which these couplings were so modified as to become readily interchangeable with the standard; citations of the following instances being illustrative:

33 Atlanta, Ga., used both 7 and 7½-thread couplings for years without serious trouble from these differences, but now uses the standard only. Watertown, N. Y., in changing to standard discovered three kinds of hydrant outlets, varying both in number of threads and in outside dimensions, all of which have been made to conform to the standard without other cost than the casting of a die, as stated by the chief of the fire department.

34 This list could be materially enlarged by naming many other towns of less prominence, which are known to have brought their equipment into conformity with the standard, while from information not yet verified, it is believed that a number of other localities have taken like action. In addition our record shows the installation of the standard in 122 localities not so listed at the date of the last issue of the Record in 1911, and as an evidence of the widespread interest aroused in this important matter of standardization, it may be stated that one prominent concern manufacturing fire hydrants, reports having filled orders for hydrants under national standard specifications for

some 46 separate towns and cities, included in which number may be named Montreal, Port Hope, St. Anne and St. Joseph in the Dominion of Canada, and the town of Aibonito, in Porto Rico.

35 The writer has models which demonstrate the practicability of so modifying either a 7 or 8-thread coupling as to produce a perfectly reliable connection when a $7\frac{1}{2}$-thread female swivel is used as an intermediary or accommodator to complete the joint.

36 The technical explanation of this seeming mechanical anomaly will be readily appreciated from the fact that threads having a V-shaped section possess the property of adjustment in relation to the accommodation of other threads of like shape, but which do not conform exactly in pitch, and which can yet be made to fit closely enough for all practical purposes. The property in question relates to the clearance between the threads, and is strikingly illustrated in making ordinary nuts, bolts, and screw joints, where clearance is required and utilized to secure a practical fit in the joint without dependence upon absolute accuracy in workmanship.

37 Keeping in mind this property of the V-shaped thread in making a comparison of the difference in clearance between 7, $7\frac{1}{2}$ and 8 thread pitch, it becomes evident that with a thread of 7 turns to the inch, the space between the crests of the threads will be 0.1428 in., while in the case of the thread having $7\frac{1}{2}$ turns to the inch its crests will be 0.1333 in. apart, and that with 8 turns to the inch the crests will be 0.1250 in. apart; hence, in selecting this standard of 3 1/16 in. outside diameter, with $7\frac{1}{2}$ threads to the inch, it will be found that by reducing the diameter of the threaded male end or increasing the inside diameter of the female ring or swivel by a fraction of an inch, the first crest of the modified male thread will fit into the valley of the $7\frac{1}{2}$ thread female ring, and that while in the progression of the spiral the following crests will not be exactly coincident with the corresponding valleys, the normal differences of clearance will be only 0.0083 in. for the 8 thread, and 0.0095 in. for the 7 thread, or less than 0.001 in. in either instance, while the reduction in diameter will be sufficient to prevent clashing of the inclined surfaces, and thus permit a fit with practically as good contact throughout the joint as if these modified threads were

of the same pitch as that of the female ring into which they are entered.

38 The foregoing facts show how cheaply and easily complete standardization may be secured. No competent mechanic can offer a valid objection to the standard as specified. It is not patented, nor is it patentable; it is but a simple adoption of common present means toward the elimination of present indefensible conditions, which continually cry aloud for the abolition of the incompetence, ignorance and carelessness which now control the selection and installation of these vital public utilities, the standardization of which is of transcendent importance.

39 Manufacturers of hydrant and other fire department apparatus will hail with gladness the day when any order for such adjuncts could be safely executed by compliance with specifications demanding conformity to the national standard, thus enabling them to discard the hundreds of couplings templets now cumbering their shelves.

MEETINGS IN BOSTON

At the regular monthly meeting of the Society held in Boston, November 15, 1913, Frederick J. Hoxie presented a paper on Dry Rot in Timber used in Slow-Burning Construction; at the meeting on December 20, H. W. Hayward read a paper on The Testing Laboratory and the Constructing Engineer. The papers, together with the discussion on each, are given herewith in abstract form.

DRY ROT IN TIMBER USED IN SLOW-BURNING CONSTRUCTION

By Frederick J. Hoxie, Phenix, R. I.

Member of the Society

ABSTRACT OF PAPER

The old idea of the phenomenon of rotting in wood was that it was an oxidation process similar to the corrosion of iron. It was shown about 35 years ago that it is a direct result of fungus.

Though in the past fungus attacks have not been sufficiently frequent or destructive to attract much attention in this country, in Germany laws have been passed relative to the sale of buildings infected with it. But even in this country poorer lumber is being used each year in factory construction, and it is rare that a pile of timber to be used in a new mill does not contain at least several sticks of North Carolina pine, mostly sap wood. In mill buildings beams infected by fungus frequently give no warning of their diseased condition until the interior is nearly destroyed. A skin of sound wood from ½ in. to ¾ in. thick is left on the surface, which quickly burns through and the building falls, as in the case of the Gledhill Wall Paper Factory, New York City. It is important therefore to define clearly and unmistakably the

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Presented at the Boston Meeting, November 15, 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

qualities of wood to be used in construction in the specifications. Simple identification by a botanical name is not sufficient because it expresses no essential quality of the material, and after a tree is sawn into lumber and shipped to a distant point it is impossible to determine from what particular variety it came. Not only is a clear understanding of the essential chemical and physical properties of the timber necessary, but also a careful consideration of its disposition in the structure. The damaging effect of a heavy coat of paint or metal covering on moist wood must also be considered, since with material of doubtful quality such treatment would be dangerous and with the best of material imprudent.

Double beams and bored columns have been used extensively in mill construction to prevent dry rot and checking in the columns as well as to make a large beam of two or more smaller ones. From a quotation in the Engineering Record[1] it appears that many mill engineers have found this of little value in preventing fungus diseases. The holes in columns as generally found are of little value in preventing checking, as comparatively few are at the center of growth of the tree. The circulation of air is so slight that the holes, instead of preventing fungus growths, encourage them. The openings between beams when covered to keep out fire also make attractive places for fungi if sufficient moisture is present, while the vertical holes when not stopped by continuous iron plates afford excellent passageways for dangerous fungi from floor to floor in a factory building.

In hard pine timber resistance to water is related to resistance to fungus and in sound hard pine, resistance to water is a function of the amount of rosin it contains. Thus it is a well-known fact that hard pine heart wood is more resistant to dry rot than sap wood. Injury to the tree or unfavorable changes in its environment may also cause abrupt change in the quality of the wood and its power of resisting fungus. The author arranged an experiment to determine whether the rosin in long-leafed pine heart wood was an important factor in resistance to fungus. A cubic block of dense fine-grained wood 2 in. on a side, containing 18 per cent rosin, was sawed in two across the grain, and half of it was boiled in benzole until practically all the rosin was removed. The solvent was driven off, and a piece of wood containing living dry rot fungus was placed between the two blocks.

[1] Vol. 61, p. 315.

The whole was placed in a moist atmosphere and the fungus allowed to grow for a year, at the end of which time a dense white growth had formed over each block. This growth was removed, the blocks dried and weighed. The specimen from which the rosin was removed had lost 8 per cent, the other only 2 per cent. Neither showed the brown color characteristic of rotten wood until after they had been dried for some time.

There are many varieties of fungus that attack wood. The true dry rot fungus, *merulius lacrymans*, is not as common as several other varieties which require a better water supply, but can remain in dry wood in a resting state for a long time, variously estimated at from 4 to 40 years, ready at any time when the wood is sufficiently moistened to start out in active growth, and according to some investigators when once started is able to provide its own water supply from the decomposition of the wood, if the evaporation is not too rapid. The disease is highly contagious and will rapidly spread from infected to sound wood.

Mr. Richard Falck[1] has shown that the thermal death point of *merulius lacrymans* and several kindred varieties is low, less than 100 deg. fahr. This has a practical application in that these fungi may be destroyed in many cases by use of the building heating system, and an experiment on a large scale in a badly infected mill goes to show that this cure can give good results, if applied soon enough; it does not, however, affect the growth of fungi in ends of beams in the brick wall where the heat does not readily penetrate. When there is any question as to the quality of the stock used in a building, heat is worth trying, and it should be done as soon as possible after the building is completed. When fungus begins to show, it is generally too late to save the affected parts.

Several of the more common fungi which destroy basement floors, fence posts and railway ties are the Lenzites and members of the Polyporus family. The Lenzites are, according to Falck,[2] capable of resisting temperatures up to the boiling point of water. These and the dry rot fungi have strands sometimes several feet long and capable of traveling for some distance across masonry or metal from beam to beam. Several varieties of microscopic molds grow readily on moist wood. H. Marshall

[1] Hausschwamm Forschungen, vol. 1, p. 53, Dr. Falck.

[2] Hausschwamm Forschungen, vol. 3, 1909.

Ward[1] has suggested the possibility of common green mold *penicillium*, acting as a wood destroyer, and there is a black mold, which does considerable damage to moist woodwork about paper mills and weave rooms, but acts more slowly than dry rot, and requires about eight or ten years to destroy a 3-in. roof plank.

Fungus is undoubtedly frequently spread by piling infected lumber with sound but susceptible material, the sticks used in lumber piles for separating the boards being a frequent source of infection. Air circulation in large piles of lumber is not sufficient to destroy the fungus, or indeed to prevent it from spreading from diseased to sound material, and the expense of a reliable antiseptic can be offset in several ways: the value of wood saved, greater economy of yard room and less expense for high piling; better insurance risk, in addition to the fact that the material manufactured from lumber so treated would be more reliable.

If fungus is found growing in a building, a careful investigation as to the extent of its ravages would be advisable. Heating and poisons can be used to destroy superficial or scattered small infections, but wood contaminated to any degree had better be removed. Fungus infected wood is more readily combustible than sound wood, and will hold fire longer. This is probably caused mostly by the better air supply in the punctured cells; another contributing cause may be waxy substances contained in the fungi. A danger from this source is that infected bearing ends of beams and columns may be burned away rapidly by a slight fire.

Diseases of timber like diseases of men have excited more interest in cure than in prevention. It is generally admitted that a building badly infected by dry rot is a difficult problem. The effectiveness of the most elaborate remedies is doubtful. Drying has been widely recommended, but can only be used where the occupancy does not involve moisture. Heating is undoubtedly more efficient where the dry rot family of fungi is concerned, but both drying and heating are uncertain with large beams or beams built into walls and deeply infected. Beam ends in walls not infrequently receive moisture from the wall and form a favorable place for fungus growth where it is difficult to detect it. Chemical curative treatments such as poisonous vapors and liquids

[1] Annals of Botany, 12, p. 565, 1898.

have unquestionable value for local attacks, but are of little use if the disease has become widely distributed, and it is difficult to determine how far it has extended.

Prevention is by far the best procedure, and much work has been done along this line on railway ties, telegraph poles, etc. Numerous antiseptic compounds have been suggested, creosote compounds and chloride of zinc being probably more commonly used than any others. Creosote, however, is objectionable in buildings owing to its black greasy nature, its somewhat increased fire hazard and disagreeable smell. The kyanizing process of treating timber with corrosive sublimate solution has been used more or less frequently with good results. Although its cost, corrosive qualities and poisonous nature have probably operated to prevent its more general use, it appears to be well adapted to treatment of factory lumber. Chloride of lime appears to encourage the disease rather than remedy it. The season for cutting timber seems to have only a secondary importance, but the dryness of the wood, whether the moisture be sap or rain water, is an important factor. Preserving timber under water prevents fungus growth while the material is in storage, as fungus cannot grow without an air supply. It may also have some benefit in dissolving from the outer parts of the wood where infection must start some of the nitrogenous constituents which serve as food for fungi. Further investigation is however needed along the line of the chemistry of seasoning and heart foundation.

Quick growing timbers will continue to come into more general use owing to their more rapid reproduction. The author's experiments would indicate that hard pine, to be able reasonably to resist fungus in building construction without antiseptic treatment, should contain about 10 per cent of rosin. Artificial saturation of wood with rosin has been tried without very satisfactory results, owing to the lack of penetration. It should not absorb over 5 lb. of water per cu. ft. in 24 hours at 70 deg. fahr. from kiln dry condition, and should weigh not less than 38 lb. per cu. ft. kiln dry. These characteristics generally accompany fine grained material, and with them fine grained material is better than coarse grained, while without them the fine grain does not appear to be a saving quality.

DISCUSSION

Chas. T. Main told of a case in his practice showing the disastrous effects of painting lumber when green. In 1872 a mill was built; the lumber was cut in the South, loaded on cars, installed as quickly as possible after its arrival and immediately painted. The timbers were white pine, the planking hemlock, and the posts oak; no heat was put on the building for some time, until after the machinery was put in. Four years later it was found that the planking was all gone; the timbers were rotted down 3 or 4 in. as well as the oak columns in the first story. The only thing that was holding the floors was the upper floor of Southern pine. Since then his company always specified that painting was not to be done until after the timbers were thoroughly seasoned, generally in a year or two. Unless there was a free circulation of dry air, floors would not last long. They were softened and weakened by being constantly wet, and would decay when subjected to wet and dry alternately. If exposed to dry but confined air, they were liable to dry rot. The most efficient method of preserving timbers was to have them well seasoned and exposed to a free circulation of dry air.

The treatment of timbers and planking to be exposed to dampness was quite common practice. Mr. Main had used with good results a great deal of kyanized planking for floors which were resting on the ground, as well as in dye houses where the ceiling or roof was exposed constantly to the hot vapors rising from the kettles. He had had occasion to investigate the condition of treated lumber which had been subject to unfavorable conditions and had found it in excellent state of preservation after many years' service.

The application of cold water paint or creosote paint did not appear to have any disastrous effects upon timber, but the application of oil paint which sealed the pores, would cause dry rot if the timber had not been well seasoned before the paint was applied.

The speaker's practice for preventing checking of wood columns was to build cast-iron wall boxes with an air space around them, and in these to rest the ends of the timbers.

E. F. Miller asked as to the method of testing beams by drilling a hole into a timber and filling it with bichloride of mercury and alcohol. Mr. Hoxie said he could tell better about this

method when some experiments on which he was at work were completed.

Some students at the Massachusetts Institute of Technology had conducted tests by the absorption of water method, but it was a long process and not practical. To prevent moisture from getting into the timber, creosote preparations were sometimes applied with a brush; poisonous salts had no power to keep out the dampness, but served to destroy fungus growth. The rosin process had possibilities, and it seemed to the speaker that it was a failure because it was put on too thick.

R. A. Hale[1] stated that his company used a liquid called carbolinium with good results. It was put on with a brush.

Dwight Seabury added that he had used carbolinium in a jewelry factory in Providence, and that it had soaked through the maple floors.

[1] Essex Co., Lawrence, Mass.

THE TESTING LABORATORY AND THE CONSTRUCTING ENGINEER

By H. W. Hayward,[1] Boston, Mass.

Non-Member

ABSTRACT OF PAPER

The many grades of materials now obtainable make it necessary to have definite specifications for everything. These specifications must be fair to both dealer and purchaser, and no more rigid than is necessary to obtain the quality of material required. Unnecessarily rigid specifications are apt to cause friction and usually boost the price excessively; and often they are not lived up to. A set of specifications should be so drawn as to insure the delivery of the exact quality of material desired and leave the manufacturer as much leeway as possible. The engineer should be familiar with the processes of manufacture in order to select the tests that are made with the special object of determining the care used in their manufacture, and the manufacturer should be familiar with the uses to which the materials are to be put. The two can be brought together by common interest in a testing laboratory where the qualities of the materials can be determined, and tests made upon full sized specimens.

There are several kinds of laboratories for physical tests of structural materials: single testing machines in works; works laboratory, special and complete; testing company's laboratory; government; and technical schools. A single testing machine in a manufacturing plant is usually operated by an unskilled man, and shows as a rule only one quality of the material tested. Works laboratories vary considerably in scope and capacity, some of them being very complete as regards the special requirements of their respective

[1] Assoc. Prof. Applied Mechanics, Mass. Inst. Tech.

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works. While being of great assistance in controlling the processes and quality of the materials produced, they do little work in any other direction. The men operating them are usually not of a high order of intelligence, and even the men in charge are sometimes rather narrow in their views and consider the makers' standpoint only. A few large companies maintain laboratories conducted by most skillful and capable men who carry on work along all lines connected with the industry and obtain valuable data, many of which are published for general information. Private testing companies do splendid work for their clients. The government has extensive testing laboratories equipped with all necessary apparatus, and is doing very elaborate research and service work. The work is carried on, however, very slowly, and no results are published until the investigation is complete in every detail. The work is done primarily for the government and private individuals must untangle a great deal of red tape before anything can be done for them. The Bureau of Standards should furnish the profession with a standard method for testing the accuracy of testing machines.

The laboratories of technical schools fill in a wide gap. In them an equipment of great variety is usually provided to satisfy the requirements of tuition, thesis work and research. In addition, technical school laboratories must be prepared to carry on commercial tests at all times, and much could be done in this connection if engineers could be persuaded to put more of their questions up to technical school laboratories at the proper time for thesis work.

The specimens for the tests to determine if a material passes specification must be properly selected, must be of the required size and shape and taken from the proper place. As a matter of fact, specimens are often submitted in an entirely unsatisfactory manner, e. g., just 8 in. long when it is required to determine the elongation in 8 in., no extra length being left for the grips of the testing machine. For testing properly the ratio of diameter to length, sufficient metal for unrestricted flow should be maintained, if elongation tests are to be considered and correct values obtained. In spite of this, one of the government specifications for a test specimen for bronze or brass castings is 1.128 in. diameter by 2 in. long in the cylindrical part, which is too short for ductility determination.

The condition of testing machines must be thoroughly watched. The weighing system is often out of order and the heads may be out of line; the latter has a great effect on short brittle specimens, such as cast iron, where the eccentric load causes a much lower strength to be

recorded than is the actual case. The screws for the buffers should also be watched.

On the whole, specimens should be tested in a manner to bring out the care in the manufacture of the material, and to show any inferior quality from any source. No unnecessary tests should be specified. Some tests usually left out of specifications are in the opinion of many engineers and manufacturers more valuable than many of those that are included, e. g., reduction of area in ductile materials, especially for high grade steel or wrought iron, instead of elongation only. Twist tests for copper wire belong to the same class. The tests specified must be as simple as possible so that they may be carried out in any fairly equipped laboratory at a minimum expense. Quantitative tests for the specifications of manufactured parts, columns, girders, slabs, pieces of machines, etc., are a much more difficult problem than the qualitative tests of materials from which they are fabricated, and can be made only by laboratories well equipped with apparatus and force. These tests must approximate working conditions as nearly as possible and must furnish data for the design of the parts.

It is encouraging to note that many engineers and manufacturers are taking up with great enthusiasm the question of testing parts of machines and structures or even complete machines, and are successfully standardizing their products. Many engineering firms with the help of testing laboratories are getting up specifications covering the complete line of materials used by them, effecting thereby a great saving in trouble and money. Much, however, remains to be done.

Many terms used in connection with structural materials are in a rather mixed state, such as elastic limit, yield point, strain, etc. Quantities that cannot be obtained exactly, e. g., elastic limit or yield point of copper or bronze, should not be specified.

New qualities of materials are being continually brought out which require special tests. This is especially true with regard to the compound steels and alloys which are being used for shafts, gears and other parts of running machinery. To determine their value such metals must be tested for repeated stress and shock resistance. About 100 letters were sent to prominent manufacturers and engineers in the United States by the Massachusetts Institute of Technology, but the answers brought nothing but a mass of variable and conflicting data, and it is still undecided just how to go to work on this subject, as regards both machines and specimens.

The variation in quality due to treatment in these high grade steels and in many alloys, make chemical tests, though of value in some cases, almost useless in others.

The author gave the following interesting information: ductile material elongates when twisted; modulus of elasticity of piece of high carbon steel is the same as for soft, within the elastic limit; a crystalline fracture on soft rivet steel can be obtained by gradual tension; steel of great strength may be very ductile; fiber rope can be made to break in the center if held by eye splices properly made and wet; steel or copper cable can be broken if held in cast sockets; best rivet steel can be nicked and bent without cracking open.

DISCUSSION

Ira N. Hollis spoke of his experiences in inspecting material for the government. One of the chief difficulties that had to be contended with was interference with inspecting officers by Congressmen. In 1885, when he was inspector for the Naval Board on Ships, he rejected a lot of shafting. The entire delegation from New Hampshire and Massachusetts in Congress appeared before the Navy Department and stated that this shafting must be accepted. It was finally accepted on the condition that the torsion test should come within the elastic limit; but what was the elastic limit? Finally the shafting was tested for torsion and snapped at a load considerably below the requirements. But for the expensive method of testing, it would have been put in the ships. The inspector's report on the process of manufacture is of more value than testing of sample pieces. Investigation of full size pieces in structures in actual buildings would be a good thing. For instance, shafting in ships has never the same stresses as when it is in the testing machine. The speaker once visited the engine room of the steamer Paris, and noticed that the difference in level between the bow and stern as distinguished from the body must have been more than an inch. What effect that has on the shafting is not clear. Professor Hollis, as assistant on the Advisory Board, wrote the first steel specifications for the Navy, and it has been said that the enforcement of these specifications has done much for the steel industry in general.

George F. Swain admitted the value of testing, but expressed a belief that there was a tendency to do too much of it than too little. In some cases the specifications of certain physical properties of the material may be sufficient, but in others, such as that of con-

crete, the process of manufacture must be especially considered. Results of tests must be used with a great deal of care.

C. E. Woods[1] spoke of trolley wire testing. The earlier users assumed that the harder the wire, the longer it would wear, and the specifications were to the effect that the manufacturer should draw the wire as hard as he could. It is only within the last few years that it was discovered that for one break due to tension there were 100 breaks due to repeated stresses, that is, the bending effect at the ears or other fixed points caused by the sudden stopping of the wave-like motion imparted to the wire by the trolley wheel. The new specifications therefore dwell more on repeated stresses than on tension. Generally speaking, the manufacturers today realize that there is a limit to the amount of money that will be paid for the various kinds of engineering materials, and act accordingly. A manufacturer at the New York meeting of the International Rubber Congress expressed this feeling when he said to a representative of one of the great American railroad systems, who complained of the comparatively poor quality of the air-brake hose his railroad was getting, "when you send your purchasing agent to get bids on hose, tell him to say that you want the best air-brake hose that can be purchased; but when you tell the manufacturers that you will pay so much, you will get the best thing there is for that money."

[1] A. D. Little & Co., 93 Broad St., Boston, Mass.

INDUSTRIAL MANAGEMENT

At the Annual Meeting of the Society in December, the Sub-Committee on Administration presented for discussion majority and minority reports reviewing the present state of the art of industrial management. These reports were printed in the November issue of The Journal. The discussion required two sessions, occupying one whole day at the Annual Meeting, and is here published in condensed form.

DISCUSSION OF REPORTS OF SUB-COMMITTEE ON ADMINISTRATION ON THE PRESENT STATE OF THE ART OF INDUSTRIAL MANAGEMENT

Charles B. Going expressed the view that there was a lack of correspondence between the title and the substance of the majority report. His impression from reading the report was that, after an introductory attack upon the analysis of the elements of industrial management, it proceeded to argumentation on its own behalf and presented, not a survey of the present state of the art of industrial management as it exists in this country, but an interpretation of a theory of management as it exists in the convictions of the majority of the committee. He did not intend to depreciate the interest of the conclusions expressed by the majority of the committee, but only to point out that these do not constitute a report on "the state of the art of management," and that they give us no more than a fragmentary idea of the conditions under which this art is carried on in the United States to-day.

A most commendable stand is taken by the committee in using the term "scientific management" descriptively, and not in the titular sense, applicable only to the Taylor system, in which it

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has often been employed. Scientific management should mean, as the committee says (Par. 36), " management using scientific methods, these being taken largely from the sciences of physics and psychology." But even with this definition in mind, the committee appears to have limited its views too closely to questions of physics and to have given inadequate attention to the questions of psychology, which, in the estimate of many students of the subject, are really paramount in the art and practice of industrial management.

Scientific management, using the term now in its titular sense, offers one method of finding standard individuals. There are other methods, forming no part of the systematic ritual of this school, which are stated to be far more effectual in discovering and distributing standard individuals. There are policies or methods of much interest, designed to better the conditions of operation with the apparently large numbers of non-standard or sub-standard individuals by whom so much of the work of industry is now carried on. Quantitatively, these schools of thought and of practice are of much importance in the existing state of the art of industrial management. The Taylor system is but one factor. There is much valuable contribution to thought and practice outside of the list of publications published in the Transactions of The American Society of Mechanical Engineers. and listed in Par. 66.

By leaving this apparently out of its consideration, and concentrating its attention upon a single factor instead of analyzing the entire equation, he thought the majority report of the committee was but another contribution to an already overburdened controversy, and that it had left the general survey not only unfinished, but scarcely even begun.

Halbert P. Gillette, while able to subscribe to many of the statements of the report, took exception to the statement that " This paper (Shop Management by Fred. W. Taylor) with the subsequent writings of the author stands today as the only comprehensive outline of industrial management."

Mr. Taylor's admirable paper on Shop Management and his subsequent writings (which are all restatements of the principles given in that paper) are so far from being a " comprehensive outline of industrial management " that one needs but to contrast the four " Taylor principles " of management with the twenty or more principles that have already been formulated

to recognize that Mr. Taylor has confined his writings to a very narrow, though very important class of industrial management principles.

In 1908, in conjunction with Richard T. Dana, the writer prepared a series of lesson papers entitled Cost Analysis Engineering which were published in book form and in which appears what the writer believes to be the first use of the term "science of management." In that book six principles of management were formulated.

In 1909, Cost Keeping and Management in Engineering, by Gillette and Dana, were published and dedicated to Fred. W. Taylor. This book contains an execution of part of the writer's original idea of writing a philosophy of management. Ten laws of management are formulated in this volume and seventeen rules to be applied in managing construction work are given, several of which the authors have in subsequent writings expanded into broader generalizations which may be termed laws of management. Since writing these books the authors have prepared a considerable number of articles formulating other laws of management, such for example as the law of plant location, the best illustrations of which may be attributed to the late A. M. Wellington, whose book on The Economic Theory of Railway Location (1887) is one of the most profound expositions of the application of one law of management which has ever been written.

The writer desires to take no credit for the pioneer work of other men, and has always tried not to be derelict in giving credit. But for such credit as may attach to the attempt to write a comprehensive "science of management" he does lay claim to priority.

While to mechanical engineers belongs much of the credit for having written discussions of the principles of management, the writer believes that members of this Society have often made the serious mistake of supposing that the whole of the science of management has come within their discussions. They have quite generally overlooked the work of such giants in the civil engineering field as the late A. M. Wellington. It is true that Wellington did not write about the direct handling of men, but he so wrote about one phase of the indirect handling of men, if it might so be termed, that he is justly entitled to place as one of the greatest authorities on management engineering. Others

before him have applied the principle of capitalizing operating expenses to determine which of two plants or machines is the most economic, but he applied this principle so minutely and so extensively as to revolutionize the practice of railway location. Indeed, he converted the art of railway location into a science by the application of one principle of the science of management.

The science of management embraces far more than the direct handling of men or the timing of the operations of men and machines. These may be scientific management as far as they go, but they do not comprise a science of management.

The science of management is a comprehensive code of demonstrable and formally enunciated laws for so directing the energies of men as to secure the most economic production and marketing of utilities.

The whole science of management usually covers five fields: (*a*) Directing the planning of the plant; (*b*) Directing the building of the plant; (*c*) Directing the operation of the plant; (*d*) Directing the purchase of materials and supplies for the plant; (*e*) Directing the marketing of the products of the plant.

The papers on scientific management that have been read before this Society have related, almost entirely, to the third field mentioned.

In developing a science of management, it has been the aim of Mr. Dana and the writer to apply the inductive method of logic in a thorough manner. The methods pursued by successful business men in all lines of endeavor have been collated and analyzed, the object being to draw sound generalizations from the data thus gathered. The generalizations drawn from these data have been called "laws" or "principles" of management. This is a process that has no kinship with the invention of a new system of management. An invention, which may consist in a new combination of several old principles, is not a science and never can be properly designated as such, no matter how far reaching are the economies effected thereby.

It seems to the writer that the public in general, and even the engineering public, has thus far failed to perceive the difference between what is scientific and what is a science. Failure to recognize the fundamental difference between what is a part and what is a whole, has led to extravagant claims for the part and consequently will lead to derision of claims that may now be properly made for the whole. Such is the potency of words

that many of the most serious errors arise solely because words are not strictly defined and strictly used according to definition.

A. Hamilton Church.[1] Of the two reports presented by the committee, the minority report raises the question as to whether the claims of certain groups of men, that they are in possession of the key to all progress, has any measure of justification.

As it appears to me, the various schools of management have not presented to us any well-balanced theory of management capable of being developed in a hundred different ways according to special needs. On the contrary, it is as if they had presented to us a barrel of gunpowder, a telescope, and a magnetic compass and claimed these mechanisms to be the whole science of maritime warfare. Certain definite and concrete mechanisms such as planning departments, stop-watches, despatching boards, instruction cards of extraordinary complexity, and special methods of remunerating labor are interesting and useful, but they do not make, either singly or combined, a science of management.

Moreover, the original claims, already generously broad, have been so expanded by some of the younger disciples that almost every modern method is claimed to be the direct outcome of the wisdom of one or another of the rival schools of scientific efficiency, and I am not at all certain but that some of the more enthusiastic young men claim that electric lighting in the factory is due to the new principles of scientific efficiency.

It is because this kind of thing has become rather notorious that the minority report is important. It would be a pity, if by inadvertence, the Society should appear to set the seal of its approval on the campaign of exaggeration that has been somewhat widely carried on in the public press and elsewhere.

Turning to the majority report, we find that the prime underlying principle of management engineering is the transference of skill. This is an illuminative statement, and I venture to think, of great practical value. It is put very tersely in the sentence in Par. 8, "the skill in shoemaking is now in the mechanical equipment of the shop." That is a clear-cut picture of a change that is already complete, and it helps us to realize exactly what is meant by the transference of skill. It also helps us to understand why, in the engineering trades, there are such

[1] Cons. Engr., 30 Broad St., New York.

wide discrepancies in the amount of work turned out by individual operators. It is because, in these trades, the transference of skill is by no means so complete. For one thing, the capacity and range of the average machine tool is large, and to some extent indefinite. A considerable amount of skill is still vested in the worker. Still more, a remarkable amount of ignorance as to what the machine will or will not do is shared by the employer and the workman.

The report shows why this is bound to be so at the present stage. In the process of transfering hand skill to the mechanical fingers of the machine, the report emphasizes the fact that more attention has been devoted to designing it, than to the problem of using it afterwards. It has been overlooked by the masters of industry that most machine tools are not specific but general machines, and that therefore a continuous study of the capacity and use of the machine is necessary to give effect to the skill stored up in it.

The more I think over this problem, the more I am convinced that the true line of progress is the exhaustive study of machines, their capacities and limitations. I have held this opinion for many years, and the system of industrial accounting I have been advocating for the past decade was, I believe, the first step made towards bringing forward the machine to its true place as a factor of production. But I must confess that until this principle of the transference of skill was brought out so clearly by this report, I did not realize exactly why the machine tool was frequently so surprisingly ineffective under indifferent handling.

I will pass over the acceptance by the committee of the three regulative principles of management, viz: (*a*) the systematic use of experience, (*b*) the economical control of effort, and (*c*) the promotion of personal effectiveness, which were worked out by Mr. Alford and myself, except to say that the credit for the formulation of these principles belongs in a larger degree to Mr. Alford than to me, and I will conclude my remarks by calling attention to a phrase used in Par. 51 of the report, viz: "the habit stage."

All the mechanism of organization in the world is valueless beside the steadiness of production that comes from the establishment of good habit throughout a plant. I will go further, and say that the whole object and end of organization should be to create the right kind and degree of habit in everyone of

the persons engaged in production, from the president down to the shop sweeper.

It is not enough for the workman to be so instructed that he forms good habit. Every living link in the chain of production requires equally to be so trained that his acquired habit is harmonious with all the rest. The report has mentioned this aspect of the question where it insists that the executives and not the workman are the persons most important to be reached. Few people understand that the principal work of an expert organizer is not the designing of elaborate blanks and cards, but the fostering, with tireless patience, of correctly adjusted habit in each member of the staff.

As the new ideals of management engineering appear to me, and this view seems confirmed by the committee's report, they may be summed up in three sentences:

Take nothing for granted.

See that every effort is adapted to its purpose.

Cultivate habit.

These sentences are, of course, merely practical derivatives from the three regulative principles referred to in the report. Each of them in turn implies other things which will readily suggest themselves. Thus, the possibility of cultivating correctly adjusted habit depends obviously upon proper mental and physical conditions for the living forces. It implies "lead" and not "drive."

It is an interesting question where the new spirit that we find abroad in industrial management has come from. To some extent, I think, it is part of a larger movement, the realization of a sense of social solidarity, of social responsibility of each for all, that is so marked a feature of the times. But it also arises, in part, from another cause. Scientific men tell us that the great difference between a savage race and a highly civilized one is that the former remains in a condition of natural innocence, and the latter has arrived at self-consciousness. This, I think, is the real state of affairs in regard to management engineering. We are passing from a stage at which there was a simple and unconscious following of tradition, into a stage of self-consciousness in which we are moved to subject our habits and our motives to severe self-scrutiny, and examine afresh every item of our daily practice. It is a very painful stage to have arrived at. Most of us are so content with our comfortable

natural innocence that we do not like to part with it, but it is a process that once commenced, must continue.

The examination into new methods of remunerating labor, the adoption, with caution, of searching instruments of analysis, such as time study, the use of precise methods of accounting—these are not causes, but *consequences*, of this newly awakened self-consciousness. It is beginning to be recognized that production is an aggregate of infinitesimal separate acts, in each of which there are three main components. First, experience must be drawn on; secondly, the resulting effort must be intelligently adapted to the end in view; thirdly, this intelligent effort must become habitual. And to secure the successful performance of these acts, the living forces concerned must be maintained in the pink of condition, both mental and physical.

C. B. Thompson.[1] A fact not to be ignored is that labor, organized and unorganized, has taken its stand, at least temporarily, in opposition to the development of scientific management. While many of the objections raised have been so unreasonable as to be abandoned almost from the start, there are three criticisms made by working men which persist in spite of explanation: In the first place, they seem to cherish an innate resentment against time study—"putting the stop-watch on them," as they express it. It "makes them nervous," "makes them speed up unduly while under inspection," "is simply another means of slave driving," "is used unfairly," "is un-American." They say also that the method of minute planning in advance and of specific instructions as to details, is destructive of the initiative which has been the backbone of American industrial progress. Further, they assert that the enhanced product due to these methods is not fairly divided between the management and the men; that an increase of 400 per cent. in production, as in the classic case of Schmidt, the pigiron handler, has been accompanied by an increase of only 60 per cent. in wages.

It is neither wise nor expedient to pass by these criticisms without comment. That they are all unmerited may perhaps be shown: for instance, it has been demonstrated that time study, carried on by one who is trained in the subject (and whose training is ethical as well as intellectual), is not unfair, nor is it

[1] Instructor, Industrial Organization, Graduate School of Business Administration, Harvard University.

used as a new method of driving, nor is it in any sense un-American. Time study has been carried on for decades in psychological laboratories for purely scientific purposes and with instruments even more refined than the despised stop-watch, but no one suggests that this use is open to criticism. When it is once clearly understood that time study in an industrial establishment, made under the proper conditions and by the proper persons, is aimed at similar scientific results, and that these results are then to be applied to work, subject to the mutual consent of employer and men, based on a conviction of their reliability and essential justice, these objections will disappear. But on the other hand, there is no doubt that time study can be and has been abused, and the working man has a right to be "shown."

Similarly in regard to the alleged destruction of initiative. Here the facts are clear. The machinist does not consider his initiative restrained when he is asked to do his work in accordance with the drawings supplied him by the drafting department. Systematic routing and planning of work and the development of a science by which it shall be done are, as the committee points out, analogous, for the production department, with the working drawing. We all believe in liberty, but we recognize, or are capable of being shown, that true liberty is liberty under law; that the artist is not in the least trammelled in his genius because he has been taught the laws under which he must use his materials; nor is the citizen any the less free because he, in common with all others, must conduct himself in accordance with the law of the land.

The problem of just distribution of the increased product is not capable of easy solution and demonstration, and much yet remains to be done in this field. No one has yet solved the problem of justice in distribution, and it does seem somewhat hypercritical to allege against scientific management that it has not done what any other movement or individual thus far has not been able to do. Rather it should be given credit for having pointed out the industrial necessity of justice in distribution, and of having proposed steps in that direction. The solution of this problem is not to be looked for from engineers. When an engineer wanders into the field of economics, he is apt to make about the same diverting spectacle that the economist would who would undertake to expound the principles of ma-

chine design. Probably the wages question will be worked out in the future as it has been in the past by neither the engineer nor the economist, but by the daily struggle and adjustment known as the "higgling of the market." In this struggle the rights of the working men will have to be conserved and enforced by organization. Only by pooling their strength can they meet the superior strategic position of the employers.

The report of such a committee as this should not have overlooked the opportunity to begin or extend the campaign of education in these particulars. Something more than education is necessary, however. Labor unions are a potent and active force in present-day industry, and we should get their enthusiastic coöperation. They are the culmination of decades or centuries of development. In spite of their numerous mistakes and injustices they have, on the whole, justified their existence; and whether you agree that they have or not, they are a condition and not a theory that confronts us. It would seem to be the part of wisdom, therefore, not to take the tack of ignoring or combatting the doubts and questionings and opposition of the labor unions, but rather to persuade them of the advisability of acquainting themselves with the facts, of recognizing the inevitability of the march of labor-saving management, and to secure their active coöperation in its development. A proposal at this time to retain their positive help in the extension of scientific management may seem Utopian, but it is warranted by certain facts and precedents in the history of trade unions. They have already established their right to determine the lighting, heating and ventilating facilities of establishments in which their members work. There are cases on record in which they have required owners of old plants to scrap their obsolete machinery and install new and modern devices, in order that the owners themselves may make sufficient profit to pay adequate wages to their employees. *It is but one step, and a short one, in the extension of this principle to say to the owner that he must modernize his establishment in every detail, not because the working man is interested in the owner's personal profits, but because only such an establishment can pay the working man the wages which his standard of living demands.*

The objections of the working men are naturally grounded in their personal experience and interest. The criticisms of the "friends of labor," however, are in most cases disinterested;

though it must be said that in too many cases they are based upon a faint acquaintance with the facts. So far as they are disinterested, they must be recognized and met. It is sheer folly to adopt the attitude of the "hard-headed business man" and display a lofty contempt for the increasing interest in the welfare of the working men, which has been developing into a powerful force during the last century. "Hard-headed" is too often a mere euphemism for hard-hearted. Intelligent humanitarianism is not only legitimate but is one evidence of upward progress, and is neither to be ignored nor treated with contempt.

But business men have a right to ask the humanitarians that they be intelligent and informed. It is the business of business men to supply the information needed from the data which are usually at their exclusive disposal. When, for instance, it is alleged that scientific management is "dehumanizing," the charge should be met with the actual histories of men who have worked under this system. Many plants where it has been developed can show, on the part of their employees, an increase of leisure, of interest in their work, of knowledge and improvement in general character, and an enhancement of all-round welfare. Mr. Taylor, and especially Mr. Gantt, have not ignored this side of the subject; but, in proportion to the mass of data in their hands, their contributions have not been full enough. This committee must have had an opportunity to look into this side of the case; and it is to be regretted that they have not improved it more fully.

In a remarkable book, Fatigue and Efficiency, by Josephine Goldmark, published by the Russell Sage Foundation, a chapter is devoted to The New Science of Management: Its Relation to Human Energies. In this chapter are pointed out the advantages of the new methods from the point of view of the working man. After enumerating the perversions to which scientific management may possibly be put, the author says: "If the unscrupulous use of scientific management were all that could be charged against it, the system could defend itself easily enough. . . . More serious is the contention that the efficiency engineers themselves have failed to gauge fairly the tax of increased productivity upon the workers. . . . What we need as regards both men and women (and the only answer which will allay the suspicions aroused by scientific management) is more knowledge as to the ultimate physical adjustment

of the workers to the heightened intensity of their tasks." And lest this seem to have too philanthropic a sound, I hasten to add the word of a prominent manufacturer, William C. Redfield, of Brooklyn. He says: "Once for all, let it be said that no management is scientific or permanently profitable which either promotes or permits human overstrain, or which taxes the future of women and children." This reflects, I think accurately, the judgment of many thinking people. The problem of the health of employees is one which demands and must have adequate consideration. No one who knows scientific management at first hand can deny that it has been given such consideration by those who are entitled to class themselves as scientific managers. Miss Edith Wyatt's investigation of the subject with reference to women workers, the results of which are described in Chap. 7 of the book by Clark and Wyatt, "Making Both Ends Meet," is conclusive on this score (and incidentally is somewhat misrepresented in Miss Goldmark's discussion). Numerous instances of the effect of this work on the health of employees might have been collected by the committee and should be given.

I know of a case of a girl who asked to be put on a task 50 per cent greater than what she had theretofore performed. At the time she appeared to be in a sickly condition. The factory nurse was consulted as to the advisability of allowing her to undertake the task and gave her consent on the condition that the girl be allowed to go back to her ordinary work if at the end of a fair period it was evident that the task was too severe for her. After the expiration of four weeks the nurse reported (and it was already evident to the manager) that the girl was not only doing the task easily but had greatly improved in health. This in the nurse's opinion, was due partly to the improved condition under which the girl worked, to the better method she had been taught, to the higher wages she received, and to her increased contentment. This same girl shortly afterward asked for an increase of 33 1/3 per cent more in her task, but this was refused.

In this report the committee emphasize the "transference of skill" as the basic feature of the new labor-saving management. Unfortunately, however, it appears that this term is used with two meanings. Throughout most of the report it seems to mean the accumulation of skill by the planning department and its transference from this department by actual instruction to the

workmen just as machinery is said to be the transference of skill, according to the report, from the designer and draftsman to the machine. The idea intended to be conveyed is undoubtedly right, but the illustration chosen is unfortunate.

Transference of skill, when considered with reference to the industrial revolution and the introduction of machinery, might easily be interpreted to mean the transference of skill from the workman to the machine. What actually happened was that the machine brought to the aid of the workmen some of the vast forces of nature; and in addition it superseded the skill of the hand worker. That this was a distinct loss to the hand worker who was unable to adjust himself to the new conditions is incontestable in the face of economic history; and the sad record of the change is a solemn warning to present day managers to take every step possible to make the adjustment to new methods of management as easy and gradual as possible. The machine developed a new kind of skill on the part of the operator; but now it is a minute skill easily acquired and subject to sudden loss with the change in the design of the machine.

The old-fashioned, all-round workman has disappeared or is rapidly disappearing; and though his replacement by the modern, keen-eyed, high-strung, quick-moving specialist is not to be altogether deplored, it has had certain serious consequences. It has made the present day operator narrower in his knowledge of industry and his skill less adaptable and elastic. It has also rendered obsolete the old methods of apprenticeship, and the present chaotic condition of this subject presents a striking illustration of the failure of managerial thought to bring about the necessary readjustments.

It seems to me important that the committee's meaning on this subject be made unmistakable. No one can reasonably and seriously object to the transference of skill to the workers by the "systematic development of a science" and "systematic training."

H. M. Wilcox[1] wrote that he felt that through the unfortunate adoption of the term labor-saving management, the committee have allowed themselves to lose the perspective of the subject of scientific management as a whole. The definition of the word science is "knowledge duly arranged and systematized, and this

[1] Miller, Franklin & Co., 17 Battery Pl., New York.

so-called new element in industry is chiefly the arranging, systematizing and recording of principles evolved by the art of management, so that the term scientific management is the most logical to use. The term labor-saving appears to have detracted from other phases of scientific management.

In a conversation with Mr. Frank O. Wells, his attention had been called to the fact that practically every industrial plant of any size had a purchasing agency for materials, but how many had a purchasing agent for labor?

H. L. Gantt. The difficulty of making a satisfactory report on the present state of the art of industrial management can be thoroughly understood only by those engaged in the installation of the new methods. The Committee have caught fully the present spirit of the movement now in progress, and Par. 45 to 58 of their report seem to me to be an excellent resumé of the subject.

In Par. 21, however, we find the following statement: "Another tendency, less pronounced in character, has as its object the improvement of the personal relations between employe and employe, and between employe and employer."

This tendency which is described as being less pronounced, I believe to be the most important part of the whole subject, for until proper relations are established between employer and employe, no system of management or training can be permanently successful.

When the methods described by the committee were first presented, many people thought that they were simply new schemes for exploiting the employe for the benefit of the employer. However false this impression may have been, it was undoubtedly widespread, and formed a serious obstacle to their introduction. How deeply rooted this idea was in the public mind can best be appreciated by reading the discussions of my paper on The Training of Workmen.[1]

Since that time the prominent writers on the subject of management have emphasized the necessity of establishing proper relations between employer and employe, realizing that no scheme that does not recognize this as an integral part can be permanent. Unfortunately this has not yet been acknowledged by everybody to be a fact. Many people value these methods

[1] Trans. Am. Soc. M. E., vol. 30, p. 1053.

only as new ways of controlling workmen for their exclusive benefit, and become interested in them only in times of trouble. Financiers seem particularly prone to take this view.

To illustrate this point, about a year ago I was consulted by a large corporation, which, however, took no further steps. Recently the same corporation was much interested in the subject of management, and I found that its employes were on the verge of a strike. The strike, however, did not come off, and the interest of the management apparently died out when the danger disappeared.

While the idea of exploiting workmen for someone's benefit is obnoxious to most people engaged directly in industrial pursuits, this is not the case with those farther removed from the workmen.

If I am to judge from the letters I received after the hearing before the Interstate Commerce Commission in Washington in November, 1910, many people thought they saw in this movement a chance to get something for nothing. So strongly was I impressed with the extent of this attitude that I felt impelled to condemn it most strongly in my address at Dartmouth a year ago. When I was leaving the hall after that address, a benevolent looking old gentleman came up and said: "Of course you will modify that before it is published?" and I did, but not just as he meant.

I regret that the committee did not include in their bibliography of this subject, books and papers published elsewhere than in the annals of the Society, for some of the very best work on this subject has been done in the last three years, during which time the Society has nothing to show. I wish to call especial attention to the work of Major Hine on Modern Organization and to that of Hon. William C. Redfield on The New Industrial Day. Both of those books, just published, will well repay careful study, as they are in accord with the democratic as opposed to the autocratic spirit in industry.

With regard to the minority report, a careful reading seems to indicate that the writer of it is practically in accord with the majority, except that he wishes to take a shot at the statement made before the Interstate Commerce Commission that the railroads were losing one million dollars per day. I must confess that when this statement was made it seemed to me rather extravagant, but a careful study of conditions for the past two

years has convinced me that the statement was conservative rather than otherwise if all preventable losses are included.

The writer of the minority report is connected with what I believe to be one of the most progressive and best managed railroads on this continent. I did a little work for him a few years ago, first, having in conjunction with Messrs. Dodge and Day of Philadelphia, made a report on the conditions in his shops. Our report expressed the opinion that his method of operating these shops was at least as good as that of the best railroad shops we knew anything about, and we visited several representative shops in this connection.

The real inefficiencies with which I came in contact on this road, however, were not in the shops. They lay in antique time-keeping, record-keeping, cost-keeping, and purchasing systems, which were run, not for the benefit of the maintenance and operating departments, but apparently to hamper these departments to the greatest possible extent. Inasmuch as most roads handle these functions in substantially the same manner, I believe that the inefficiencies of railroad operation, due to the lack of appreciation by the financial end of the needs of the operating end, are far greater than those over which the operating end has absolute control.

Railroads are built nominally to earn money for their stockholders by the sale of transportation. If this were the only way they could be used to get money, all activities connected with a railroad would be so run as to assist in the economical production of transportation, just as all the activities of a well run foundry are harmonized for the production of castings at low cost.

As a matter of fact, the financial end, including the purchasing, store-keeping, time, cost, and record keeping, does not as a rule consider economical operation as any of its affair, but puts this responsibility entirely up to the operating force. The best railroad managers of today, however, see that real economical operation cannot be had unless all functions contribute to that end, just as they do in the best managed factories.

Unfortunately this is a view that the average financier finds difficulty in accepting, especially if he has always been a financier. A proper comprehension of this subject, however, is the best way to head off the growing sentiment for the government ownership of railroads.

Turning again to Par. 21, concerning the relations between

employer and employe, any scheme for the training of workmen, or promoting the transference of skill, if that term is preferred, to be ultimately successful must carry with it a guarantee on the part of the management that the employe shall receive his share of the product of his increased efficiency or skill. Increasing the efficiency of a workman thus differs radically from increasing that of a machine, which claims no share of the results.

If, however, the attempt to increase the efficiency of the workman is made in such a manner as to lead both employer and employe to feel that he is getting what he should from their mutual efforts, the promotion of efficiency is sure to follow, and we have a working basis on which to attempt the solution of some of our industrial problems. As long, however, as such prominent men as Mr. Parry and Mr. Kirby of the National Association of Manufacturers continue to use such language as they have in the past in speaking of workmen, just so long will the workmen continue to use brute force in dealing with employers, and a satisfactory solution of the labor problem be delayed.

The implication in the report of the committee that the development of methods and the training of workmen are functions of the management has to my mind not been sufficiently emphasized. The piece-work system as usually operated, and most of the premium and bonus systems in general use do not recognize training as a function of management, and may be classed as individual effort systems. They have undoubtedly accomplished some results in the past, but we have now reached the stage in our complicated industries where more than individual effort is required. Individual effort may be so hampered by environment as to make progress impossible, and to cause the workman to become so discouraged as to give up whatever effort he may be making. On the other hand, if the management determines that a certain degree of efficiency is attainable, accepts the responsibility of training workmen up to the point necessary to obtain that efficiency, and provides means for obtaining it, we have an entirely different condition.

This view of the subject is so opposed to that held by most managers, superintendents and foremen that it is with great difficulty that we can get them to accept it, and the time needed to bring them around to this viewpoint is far greater than most realize. There are many reasons for this, and the fact that a

man does not instantly accept a new proposition, which is to his mind revolutionary, should not for one minute be held up against him, for a strong man who has been successful in following one line of action, justly regards an entirely different line as being inferior to one which has brought him his success.

Fig. 1 represents the work of women winding yarn in a cotton mill after the system had been in effect one month, at which time three operatives were regularly earning a bonus. At the start, one of the best workers was offered the opportunity to perform the task and to earn bonus, but she felt the task was too severe and did not wish to try. A week later, however, she did begin the work and made her bonus right along. Some of the people in this room were young girls who apparently had but little interest in the work and made practically no effort to earn their bonus. The older and more staid ones, however, took hold promptly and the younger ones gradually dropped out. The newcomers at first spent three or four weeks before they actually earned the bonus. As, however, those who were not interested in earning the bonus gradually disappeared, the habit or fashion in that room came to be—attend to your job and earn the bonus. The newcomers then in many cases earned their bonus from the very first day. This chart is dated March 1909. Fig 2 shows a chart of this room as it exists today and is reproduced by permission of the treasurer of the mill.

Some months ago the Industrial Workers of the World made an attempt to cause a strike in all of the mills in the town where this mill is situated, and actually succeeded in shutting down some of the mills for several weeks. In this mill, on which a strong attack was made, only 60 out of 600 employes were drawn out, and the management had no difficulty whatever in filling all their places in a few days.

Fig. 3 represents the work of girls in a worsted mill. The best workers were put on bonus work first. Their improvement is noticeable. It was nearly three months before all were put on this work. The poorer ones failed at first, but on the last day shown on the chart all of the poorer workers earned bonus. During the period from April 15 to July 10, one-hundred and sixty-one girls had been put on bonus work, and 21 out of this number had for one reason or other left the employ of the company. The reasons were as follows: four left on account of poor health or were dissatisfied; one married; one entered a convent; one went

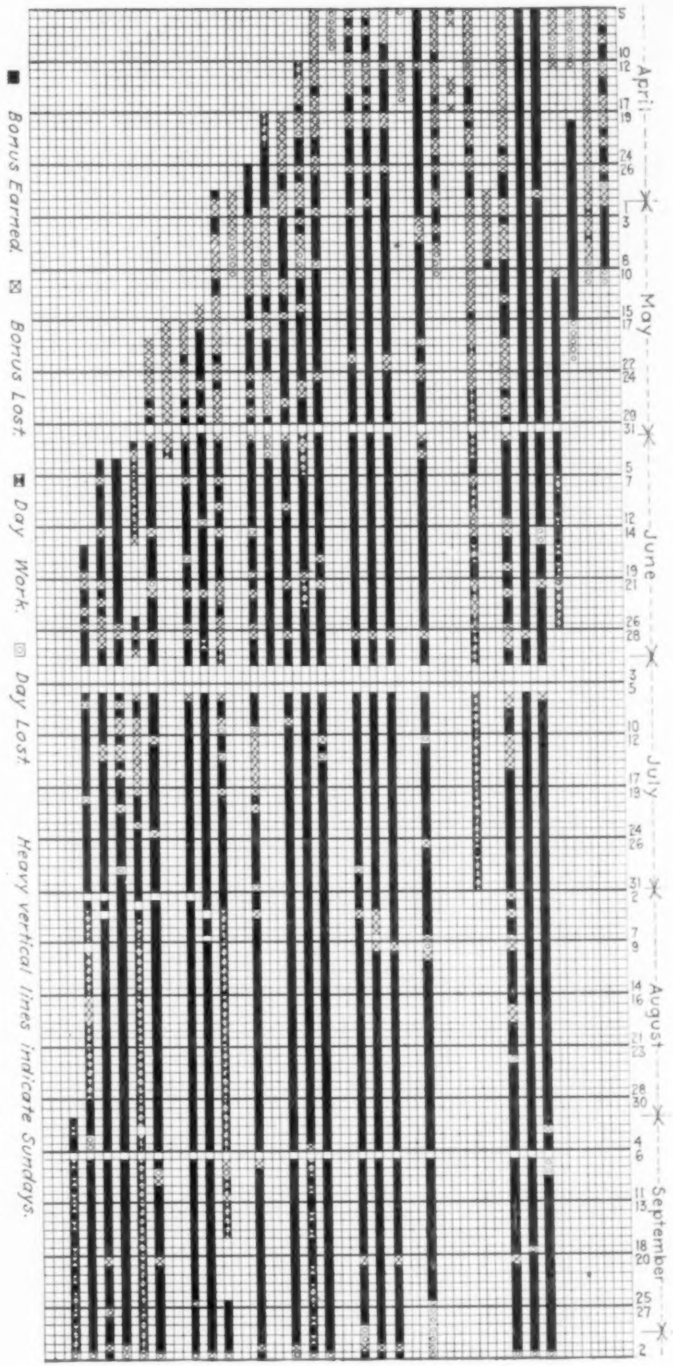


Fig. 1 Chart showing Results of Bonus System: Women winding Yarn in Cotton Mill, 1909

Each line is the record for one worker. Note how much more quickly new workers put on in June began to earn bonus than did those in April or May

to work at the mountains for the summer; five left town and nine were discharged.

One of the obstacles nearly always encountered is the opposition of certain people in authority who, having once expressed their disapproval of these methods, feel it their duty to oppose

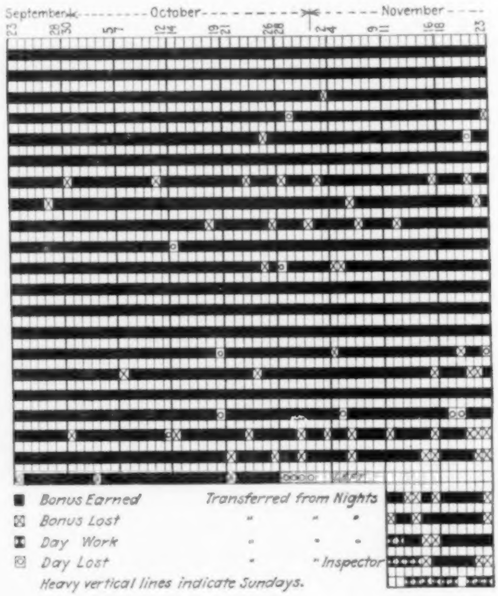


FIG. 2 CONDITIONS EXISTING IN 1913 IN THE DEPARTMENT REPRESENTED IN FIG. 1

their introduction to as great an extent as possible. Their original arguments having failed, the argument that we were overworking the girls was advanced and they insisted on being allowed to put on piecework some of this work which was in another building, and which had not yet been put on the task and bonus system. Accordingly, on June 19 their piecework was started. On July 11, the date of the report, 19 out of a total of 53 girls in this building had left. In other words, almost one-third of the girls who were put on piecework according to the request of the man who had their interests most at heart, left in three weeks. In the case of our bonus workers, approximately one-eighth of the girls left in 15 weeks.

In 1904 I put this system into a shop making packing boxes. A few weeks ago I had word that it was running substantially

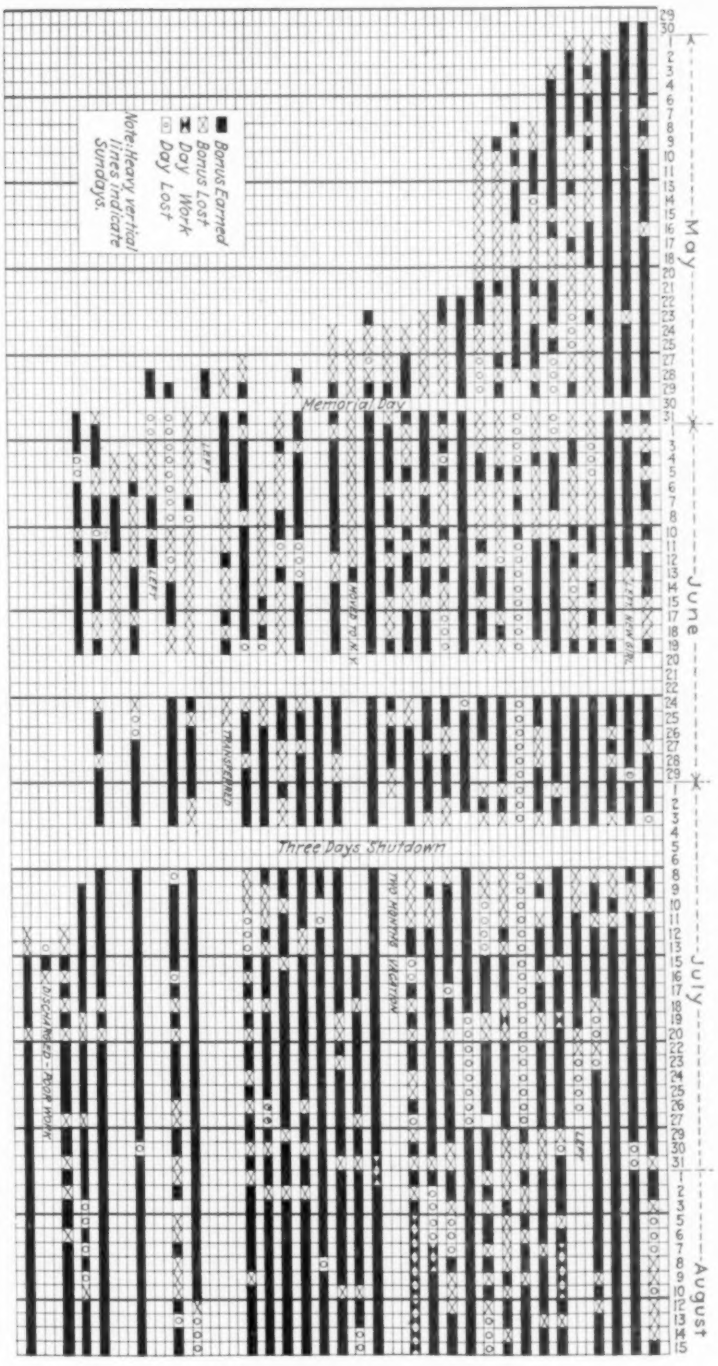


FIG. 3 RECORD OF WORK IN WORSTED MILL

Each line represents one worker. This is a sample chart for one room. There were several other rooms

as it was started and that nearly all of the original bonus workers were still there.

Fig. 4 represents the making of sheets and pillow cases and the work of starting the task and bonus was done by a man who had been connected with me, but who was doing this on his own responsibility. I was not personally in touch with this work when it was done. The factory was shut down on a number of days, November 28 (evidently Thanksgiving day) and then on Christmas and all Wednesdays and Saturdays for the next two weeks. The work started off very well, but the rush to get people on bonus on November 30 evidently upset things, for a number of workers are back on day work. This was probably due to the inability of the task setter to set tasks on new work fast enough. Just before Christmas week the same condition obtained, and after Christmas there was not enough work to keep the factory running full. However, by the middle of January those who had bonus work were beginning to earn their bonus pretty regularly, and by February 10 the number of workers was just about large enough so that each could be supplied with a full amount of work. From that time on the work went smoothly.

It is evident from this chart that the management has its part to play in supplying work and teaching workers, and that the trouble was not with the workers but with lack of proper balance in the managing department. The fault, however, is a natural one, for when the man responsible for the output finds the advantage he can obtain by the task and bonus system he almost invariably insists on putting as many people on bonus as possible, with the result that he finds he cannot supply all the workers properly and that numbers of them have to be put back on day work.

You will ask why the task setter does not explain this to the superintendent and make it clear that that is the wrong way to do. I can only say that no amount of explanation on my part, or that of my representatives, seems to have much effect and we have about come to the conclusion that the best way to do is to let them make their mistakes and find out, then the question is settled once and for all time.

Fig 5 is a particularly interesting chart inasmuch as it is the most recent—the development is still going on. It is reproduced by the courtesy of the manager. In this the work went

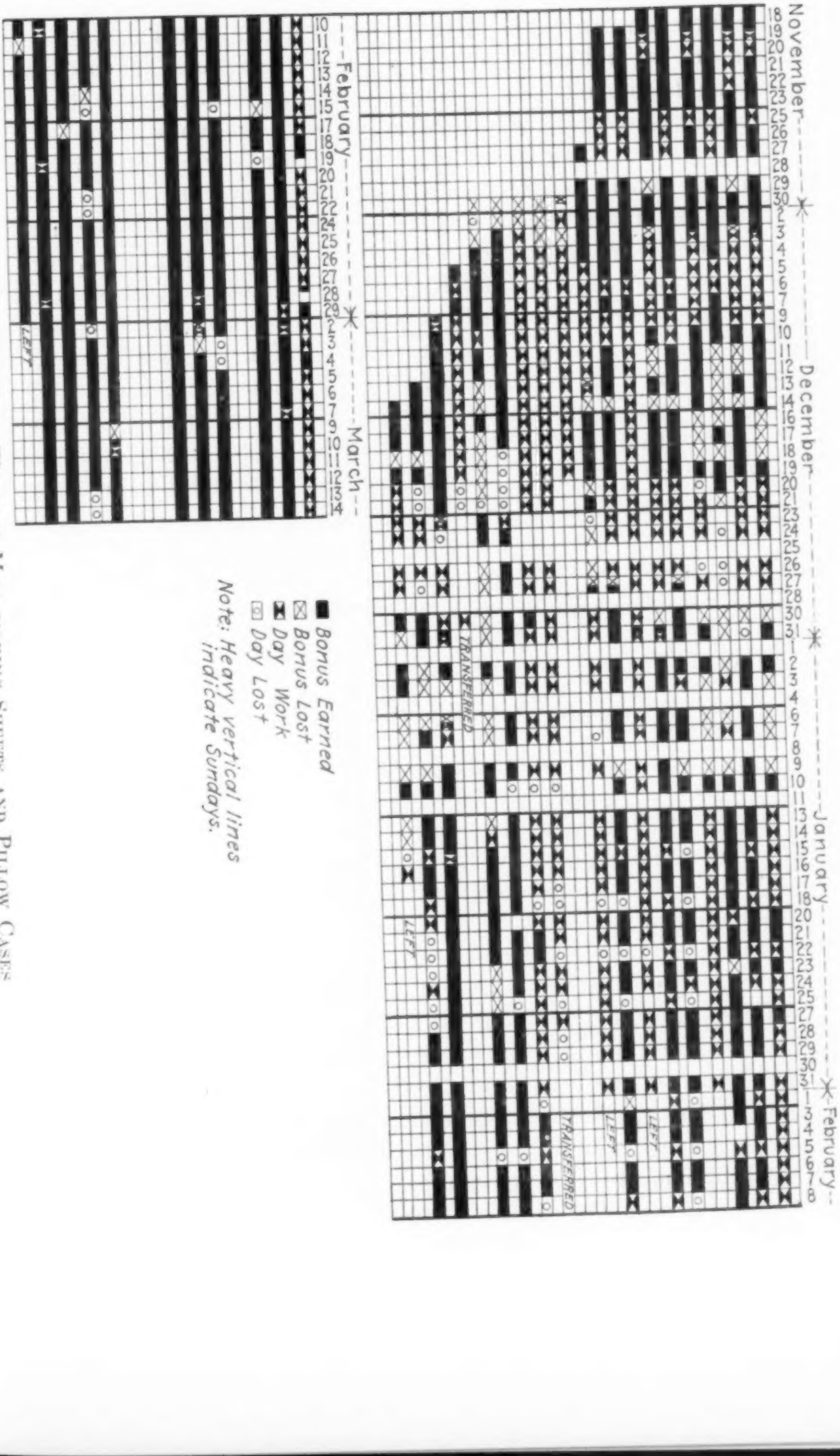


FIG. 4 RECORD OF WORK IN MILL MAKING SHEETS AND PILLOW CASES

very well until we began to push it too fast. When the desire to get an increased output overcame the conservatism with which it is necessary to establish a new method, those workers who were last put on influenced the others not to perform the task, and on one day nobody made bonus. One girl, however, felt that she needed the money and continued on with the work. The others showed their hostility toward her in a number of ways, but she still persisted. After they had ceased to try to do the work for three or four days, several of the girls sent in their notice that they were going to quit. They were evidently trying to raise an issue, but inasmuch as the management ignored it and went about its business of getting conditions so perfect that the workers could have no cause whatever for not trying to earn their bonus, they were unable to get the issue accepted. At the end of eight days some of the girls became willing to try again, and from that time on the number increased. For some time past the applications from other girls to work on task and bonus has been so great that we have been unable to provide proper conditions and to set tasks for them fast enough.

The question naturally arises with respect to the charts as to the ratio between the amount which is being accomplished now and what was accomplished previous to starting in with this work. In order to make these comparisons clear we devised what is called a Percentage Chart. On this the average production previous to the installation of our methods is called 100 per cent. Our new production may be two, three or four times that amount. The wages paid before the work was started are also rated at 100 per cent. The new wages would be an increase over the old standard, usually of from 30 to 50 per cent and the wage cost measured in the same manner would be distinctly below the previous wage cost.

Fig. 6 shows these ratios with regard to work done several years ago in a bleachery in Rhode Island. Each of the vertical lines represents a different kind of work. The horizontal black line marked 100 per cent represents the amount of work which was done on each of these operations previous to our investigations. The upper lines represent the amount of work now being done, compared with what was previously done. The heavy black line marked 100 per cent also represents the previous wages paid, and the dotted lines above it represent wages now paid. The 100 per cent line also represents the previous wage cost. The

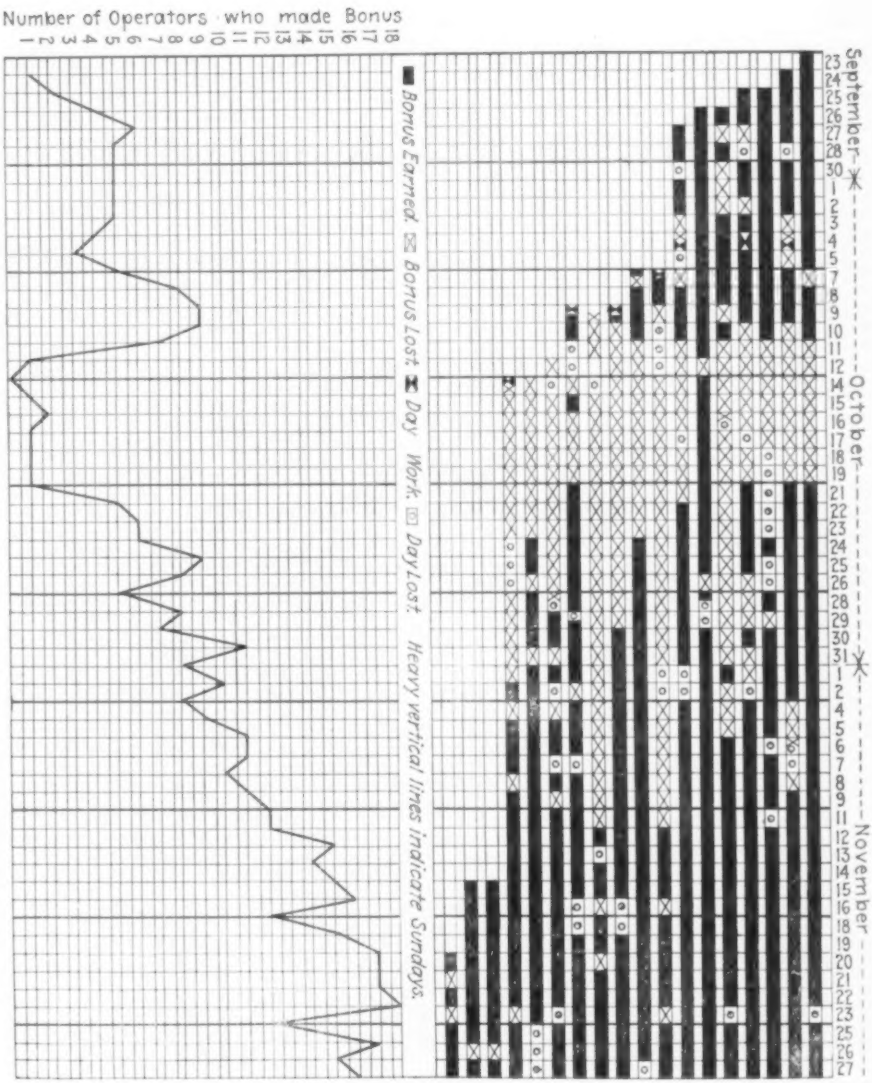


FIG. 5 CHART ILLUSTRATING BONUS WORK IN FACTORY WHERE THE EFFORT WAS MADE TO INCREASE THE OUTPUT TOO RAPIDLY

dotted line below represents the present wage cost. The increase in product is around 200 per cent and the decrease in wage cost is approximately 40 per cent, while the increase in wages is also 40 per cent. It should be borne in mind that *this increase in product is not due solely to the work of the operative, but also to more careful study and coöperation on the part of the management as well.*

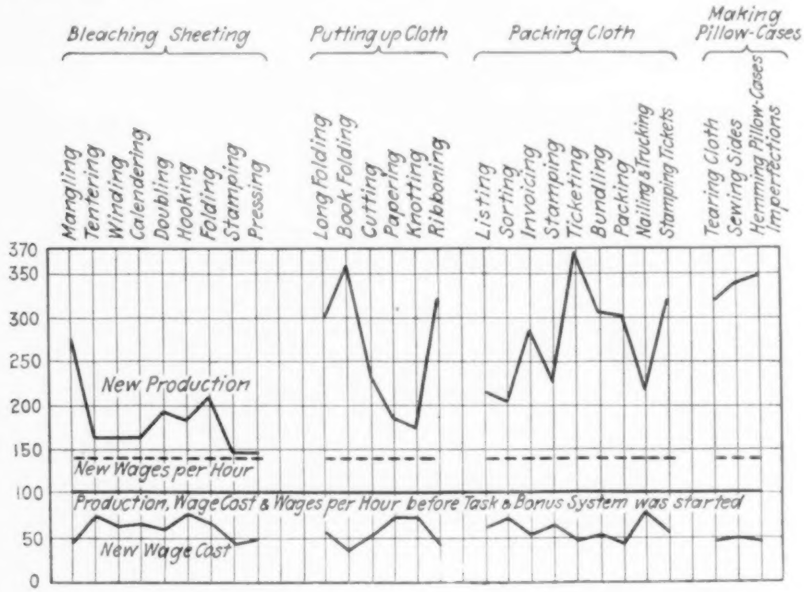


Fig. 6 Actual Results under the Task and Bonus System after more than Two Years' Operation

Each Vertical Line Represents a Different Operation

Fig. 7 shows similar results for work on small automatic screw machines. In this case the light line represents the task; the upper heavy line the amount of work done; the upper dashed line the wages now being received; the lower dashed line the new wage cost. In this particular case the shop was well run before we undertook to study the work, and the workmen were getting good wages. The increase in production is not quite so high as in Fig. 8 which shows similar results for large automatic machines. Fig. 9 represents the same change for miscellaneous machine work in a plant manufacturing a small article in quantities.

Comparing all four of these charts it will be noted that there

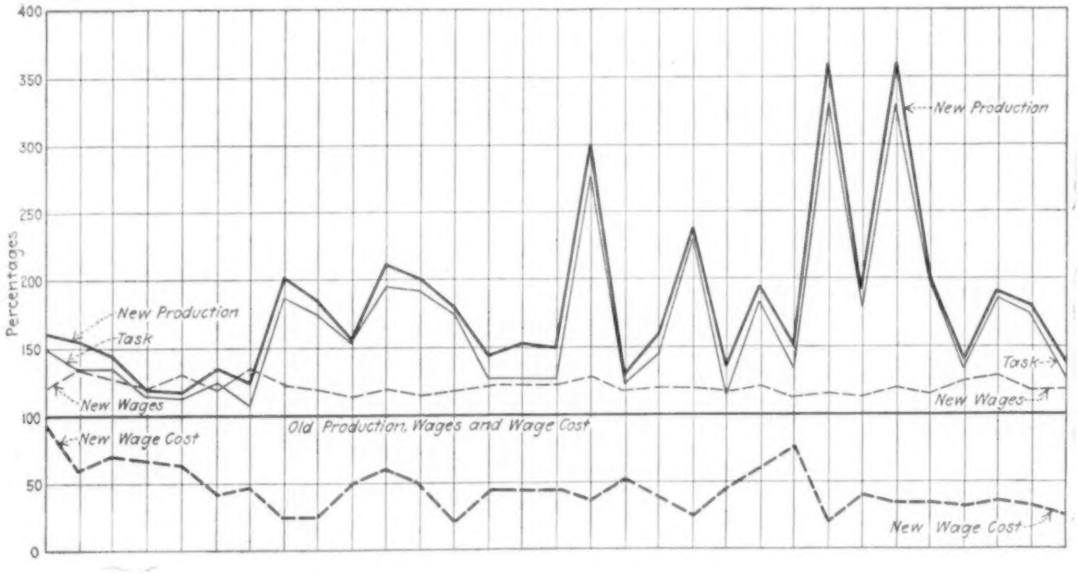


Fig. 7 Wages and Production Diagram on Automatic Screw Machine Work
Each Vertical Line Represents a Different Operation

is a very striking similarity whether doing handwork in a bleachery or automatic lathe work in a machine shop. If the management assumes its share of responsibility in preparing the work, in seeing that the machines are in proper condition, and in training the workmen, we can get from two to three times as much work done as is usually done, pay 20 to 50 per cent increase in wages and still save about 40 per cent in wage cost.

This increase in output brings down the overhead expense on every unit of product so that the decrease in wage cost is not the only important item. It is not even the most important.

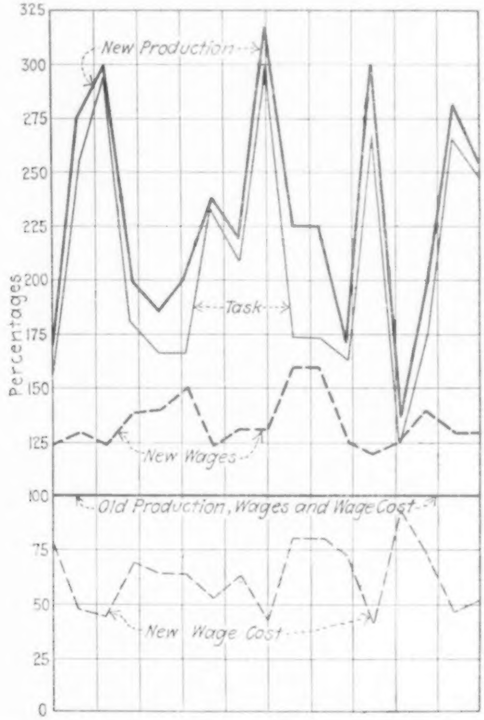


FIG. 8 WAGES AND PRODUCTION DIAGRAM ON LARGE AUTOMATIC WORK

Each Vertical Line Represents a Different Operation

Unless the overhead expense is markedly increased when the product is increased this expense per unit of product comes down substantially in inverse ratio to the amount that the product goes up. The reduction in cost from this source is usually markedly greater in dollars and cents than the reduction in wage cost. This side of the cost question has been given too

little consideration. Andrew Carnegie was among the first men in this country to recognize the great value of getting a larger product from his plants, and this, perhaps more than any other fact, gave him the mastery of the steel business. Many times we can afford to pay even a higher wage per piece if thereby we can reduce this overhead expense. In general, however, a thorough study of the work enables us to reduce both wage cost and overhead expense per unit of product at the same time substantially increasing the earnings of the workman.

In Fig. 9 will be noted a discrepancy in certain cases between the task set and the amount of work performed, showing that the workman did a great deal more than expected. It is asked, naturally, how we could overcome this difficulty, for many would feel at once that a serious mistake had been made and that the tasks should be increased or the rates reduced.

In reply, these tasks were set by a task-setter who had not had sufficient experience. We, however, do not consider that because he has made an error that it is necessary for us to change the rates. As a matter of fact, we rather prefer that there should be a few easy tasks so that the workmen may have a practical demonstration of the fact that we are not going to cut rates and that they need have no fear whatever if they do all the work they can and earn all the money possible.

Another comment may be that these shops must certainly have been run very badly before. While some of them perhaps were not in the class of well run shops, others were, and high up in the class. Before the introduction of these methods the results achieved were due to the effort the workman put into his work, with but practically little direct assistance from those over him. After the methods were installed he was taught the best way of doing the work that we could devise, offered a substantial reward for accomplishing the desired results in the manner in which he had been taught, and the conditions under which he was working were so modified that these results could be accomplished if the worker had been properly trained. In other words, these results are not accomplished by the workman alone and unaided. He had the thorough coöperation of a strong management.

Another criticism may be that no account is taken of the indirect labor, such as transportation, clerical work, etc. In reply, we find as a rule that there has been even less attention given to

the proper study and planning of indirect labor than to direct labor, and that the chance for improvement in that line is quite as great as, if not greater than, in the line of direct labor.

My object in presenting so many charts which illustrate the same thing, is to show to as great an extent as possible that the principles laid down in this discussion are of wide application:

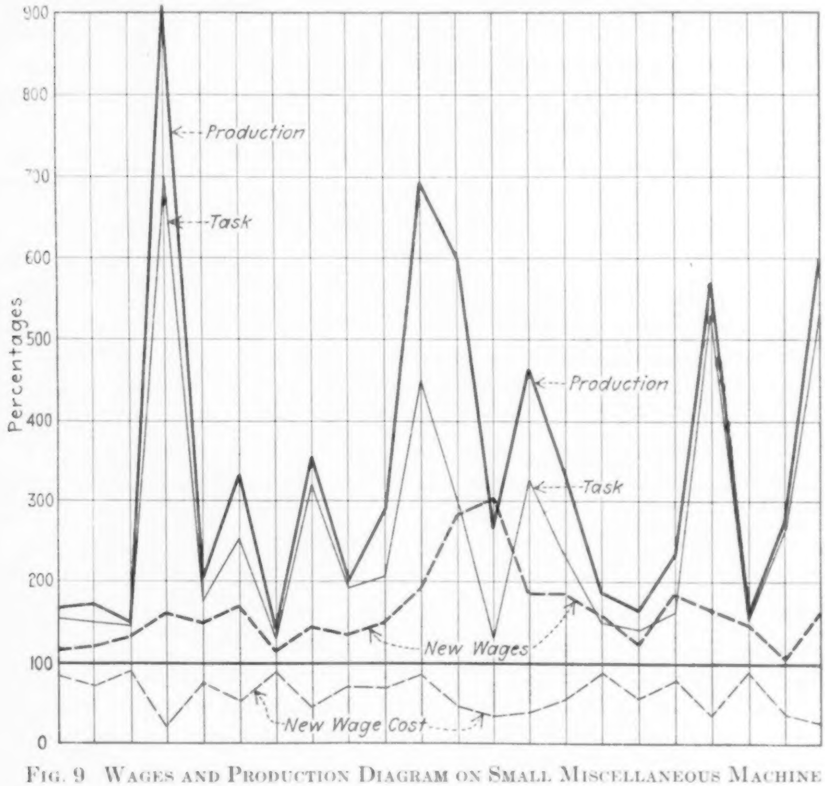


Fig. 9 Wages and Production Diagram on Small Miscellaneous Machine Shop Work

Each Vertical Line Represents a Different Operation

and that in all cases substantial results may be expected if these principles are properly carried out.

The essential point in carrying out these ideas properly is that they should be *understood, and thoroughly appreciated by the people who undertake their application.* The results shown cannot be accomplished unless we have harmonious coöperation between employer and employe, which is impossible under the form of management which assumes that the responsibility of

the manager has ended when he has issued his instructions to the shop.

To my mind, the training of workmen to fill all the different positions in a factory is one of the important functions of the management, and we all know that training is slow and expensive, but it is the only method which holds out any hope of producing even a partial solution of our present industrial problems. This training cannot be accomplished by following blindly a lot of rules. The men responsible for the training must understand clearly the reasons for every step before they can teach employes to follow them intelligently.

JOHN G. ALDRICH. I believe that the report of this Committee is right. Scientific or labor saving management is scientific measurement and everyone will agree that this is desirable. The importance has been pointed out in this report of the study of production by scientific methods and of setting up standards. It is impossible to make up standards without first making a careful study of the correct motions and of the times required to make them.

The New England Butt Company, of which I am manager, is doing some work along this line to which I would like to call attention. This company builds largely machinery for making braids, such as trimmings for ladies' dresses, shoe strings, coverings for insulated wires, etc. The machines are made up mostly of small light castings which are machined but little, but which must be well made so that the parts will fit together without filing or other hand work.

Within the last few years with the help of various experts we have continually made improvements in our manufacturing departments. Time study was made of different operations and of different methods and proper times were set on those methods upon which to base the various systems of payments for work performed. We are now using a method of time and motion study which has not been used before, and which not only gives more accurate results than have been heretofore possible, but also enables us to discover methods that are much more economical.

This method consists of taking motion pictures of the various operations with a special moving picture camera, and photo-

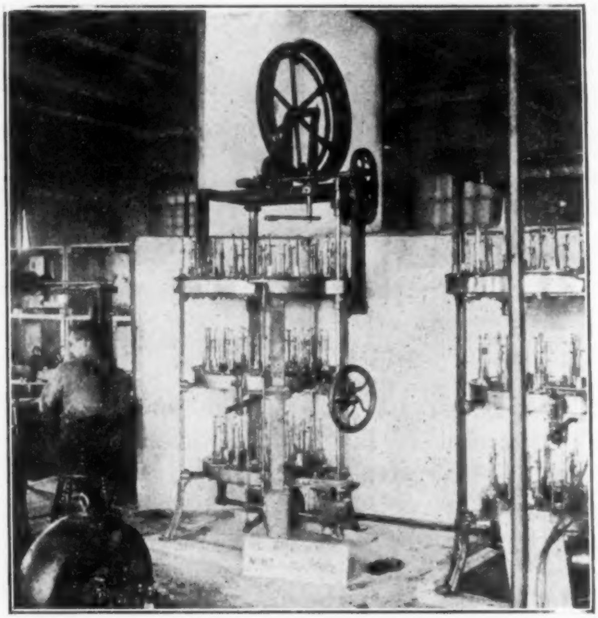


FIG. 10 DOUBLE DECK BRAIDING MACHINE

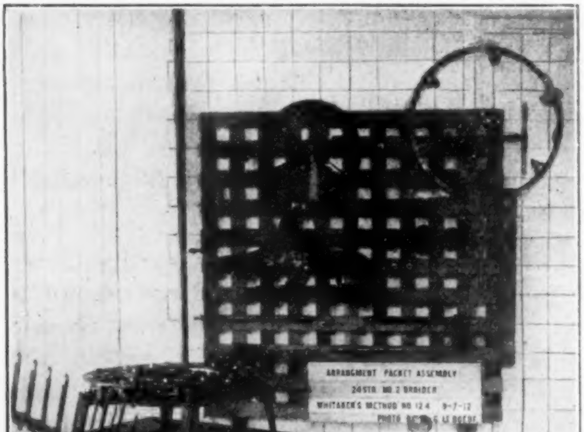


FIG. 11 TYPICAL PORTABLE ASSEMBLY BENCH AGAINST PACKET WITH THE PARTS ARRANGED FOR ASSEMBLING A BRAIDING MACHINE

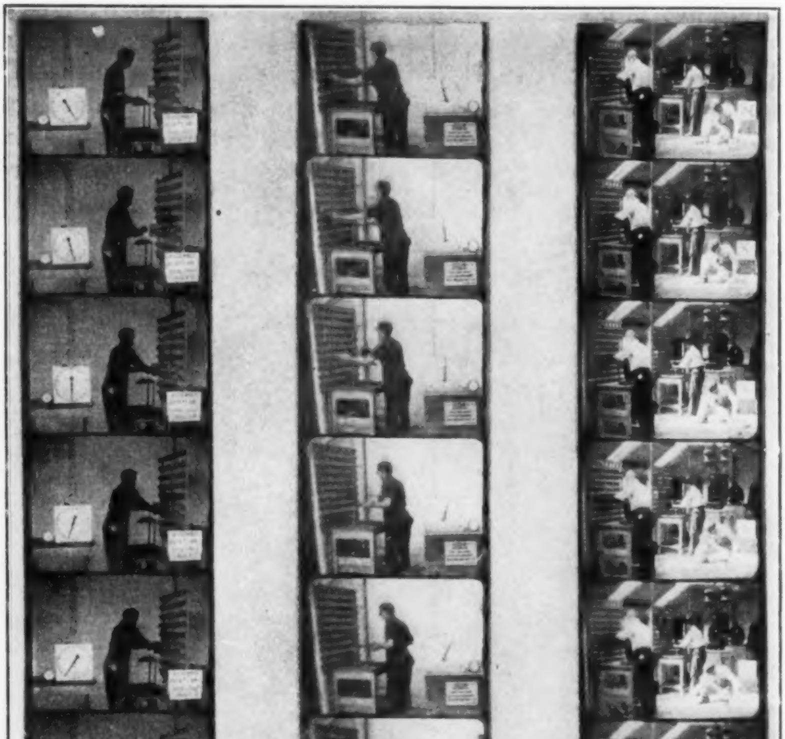
graphing in each picture a clock of special design showing minute divisions of time. The hand of this clock revolves once in six seconds so that the divisions represent thousandths of a minute and are easily read to half thousandths. The continuous motion picture film furnishes permanent record of times and motions. To develop improved methods this film is afterwards studied with a magnifying glass and it is not necessary to project the pictures on a screen.

Before taking these pictures considerable study was given to-

Fig. 12 Motion Picture Machine Recording the Motions of a Workman

ward eliminating waste motions and otherwise improving the conditions under which the work was done. In assembling machines, instead of picking up the pieces to be assembled from various boxes, packets were arranged with the parts placed in convenient positions, and also placed in the proper sequence, so that no mental process was required of the workman to determine or select the parts to come next.

Since using this method, which we have designated micromotion study, previous times have been reduced over two-thirds. Its records have suggested to us methods that now permit in one



IGS. 13, 14, 15 SECTIONS OF MOTION PICTURE FILMS OF WORKMEN ASSEMBLING A BRAIDING MACHINE

case doing work in $8\frac{1}{2}$ minutes that before using micro-motion study took $37\frac{1}{2}$ minutes.

Par. 6 of the report calls attention to a most important principle, "the transference of skill." Micro-motion study furnishes a means for the transference of skill from man to machine. More important than this it furnishes a means for the transference of experience from a man who has had it to one who has never had it. We have used micro-motion study for determining the cor-

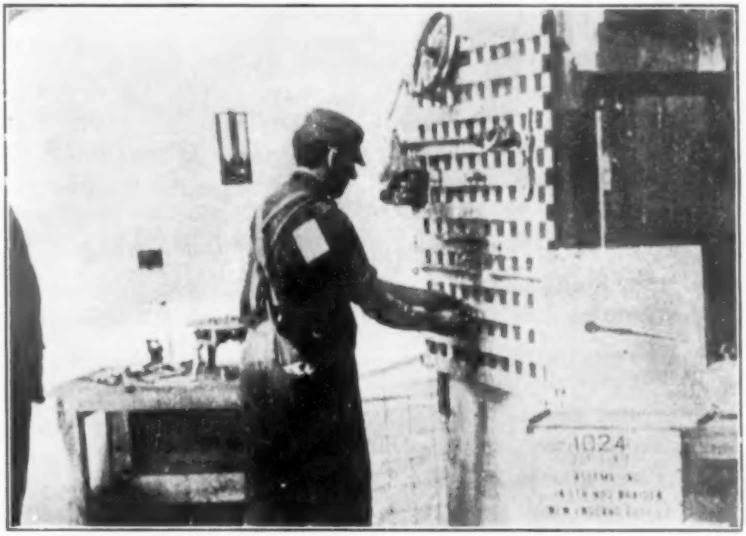


FIG. 16 ENLARGEMENT OF ONE PICTURE OF A MOTION PICTURE FILM

rect times of the best motions in many different kinds of work. It is the least expensive as well as the only accurate method of recording motion and time study data. A few illustrations will give a clear idea of this process:

Fig. 10 shows one of the styles of braiding machines which we build and to which we have applied this method of time and motion study.

Fig. 11 shows a typical portable assembly bench against a packet with the parts arranged for assembling a braiding machine with the fewest and shortest motions.

Fig. 12 shows the motion picture machine recording the actual motions of the most skilled workman. It also records the subdivisions of each elementary motion. It will be noticed that the floor and background are both marked off into 4-in. squares.

The object of this is to enable us to place the bench in the most desirable location and to see that the workman stands in the most convenient position. Furthermore, it enables us to determine the lengths of all motions.

Figs. 13 and 14 show sections of two typical motion picture films of a workman assembling a braiding machine. The clock can be easily seen in these pictures and by means of it the times of each elementary motion can be determined. In the consecutive views the clock shows elapsed times of three one thousandths of a minute.

Fig. 15 shows a section of a motion picture film with several workmen assembling the same kind of machines. It shows how different operations are recorded at the same time for future study, thus reducing the cost of time study. It also shows how the performance of a number of men on the same kind of work can be compared.

Fig. 16 shows an enlargement of one of the pictures of motion picture films.

From the above it will be realized that micro-motion study enables us

a To capture the experience of the most skilled workman and record it for the benefit of all.

b To determine the motions of least waste.

c To teach the best known methods only.

d To analyze, measure and compare new data so that improved methods may be constantly standardized as fast as discovered.

I believe that the time will soon come when we will have a national bureau of standards of best methods, and micro-motion study will provide a means that the government can use for collecting and recording the best practice of the workmen in our industries.

Robert Thurston Kent. Underlying the three regulative principles given in Par. 41, is a greater one which renders them all effective—the principle of measurement. Micro-motion study is the most powerful tool ever offered the engineer to measure the efficiency of the worker. The moving picture machine together with a specially constructed clock which will measure time intervals to the half thousandth of a minute, presents a means of studying operations or cycles of operations which occur

too rapidly for the eye to follow and which, therefore, are impossible of study by the ordinary method of an observer with a stop watch.

Time study is the basis of all modern management. The provision of a machine to make time study should be as revolutionary in the art of time study as was the invention of the power loom in the art of weaving. Among other things it absolutely eliminates the human equation. It provides a method in which there is not only no possibility of error in measurement, but which furnishes at once a true statement of the time elapsed in the performance of any operation and a record and instruction card of the best method of doing a job.

In The Psychology of Management the following statement appears:

> Measurement is a most necessary adjunct to selecting the workers and the managers and assigning them to the proper functions and work. They cannot be selected to the greatest advantage and set to functionalized work until (*a*) the unit of measurement that will of itself tend to reduce costs has been determined; (*b*) methods of measurements have been determined; (*c*) measurement has been applied, and (*d*) standards for measurement have been derived.

It is obvious that micro-motion study at once presents a means of most economically determining and applying all these standards.

It was the writer's privilege to be present at many of the experiments which led to the development of micro-motion study and to observe how it was applied to the transference of skill and experience. Scientific management makes use of the best methods of all trades which can be transferred to the trade under consideration. The experiments under which micro-motion study was developed are an illustration of this point. The work involved was the assembling of braiding machines, obviously a machine shop proposition. The original method of assembly involved the bringing of the various pieces to the job in a box or boxes from which they were taken as required by the worker. Many unnecessary motions were used to transfer the individual pieces to the growing machine which were promptly revealed by the moving picture machine. A bench which would bring the top of the completed machine at a convenient level for the workman was built and the parts were arranged in an orderly manner in bins behind him, thus reducing the number of motions.

In other trades in which some of the experimenters had been

engaged it had been found advisable to group the units composing a single assembly on a packet arranging them in the order in which they were needed. This suggested a similar packet scheme for the parts of the braider. A horizontal packet was first made up and the motion picture machine revealed an irregularity and lack of rhythm in the movements of assembling which seriously cut down the efficiency of the workman. A change to a vertical packet and a standard height of portable assembly bench was thereby indicated. On this packet the various parts are hung on pegs in that exact position which micro-motion study has revealed as the most economical of motions both as regards time and length of travel. Micro-motion study revealed the deficiencies of previous methods and permitted the development of the final accepted methods in a small fraction of the time and expense which would have been necessary under conditions existing before its invention.

F. A. Waldron. Literature on scientific management has dwelt largely with the labor problem, while the other elements which tend so much toward maintaining factory output have been to a large extent ignored. Scientific management in its highest sense can be likened to the proper functioning of the human body, in which each part carries its own portion of the load, does its own share of the work at the proper time and distributes energy in proper proportions to all parts of the human frame.

There has been more or less tendency in the management of industries to divorce the financial and sales organizations from the factory or shop management in such an arbitrary manner that the two act in a way indicating that each is working for itself regardless of the broader interests of the company of which each is a part. So long as the sales end can get orders to the factory and be duly credited, the fact as to whether this order contains enough specific information to complete it, is ignored and it is left for the factory to make it out as best it can. A serious loss in volume of output may thus be caused. I can recall several instances in my experience where an output of from $50,000 to $100,000 worth of business was held awaiting detailed information on minor items before the order could be shipped. It is essential to keep the entire organization in balance. Do not overload sale and advertising departments if the factory cannot

handle the work. Build up on a solid foundation surely and gradually. Educate not in the factory alone, but along the entire line.

Output. In the excitement of the moment, the quality of output should not be lost sight of. This cannot be maintained by the mere placing of tools, instructions and drawings in the hands of the workman. Men must be trained and it takes time and money to train them. Unless this training embodies the elements of thoroughness and completeness, they become half-rate and slip-shod men, looking for pay day and taking little if any interest in the work.

Ideal factory conditions rest almost entirely on one basic principle which is *constant volume of output.* It is not always possible to maintain this owing to conditions that may arise, such as orders, capital, and the proper supply of materials and help. Every green workman broken in means sacrifice in profits, quality and volume of output. As these weak spots develop, however, we should try to build them up in such a way as to make conditions tending towards constant volume of output, as nearly perfect as possible.

It is far better to work at a steady even gait for a year than to intensify the production to a point where all the work is done in six months and your factory is idle for the remaining six months.

The extent to which time study should be carried depends entirely on these conditions and the expense incurred by ultra-refinement could better be invested, oftentimes, in raw materials or finished stock of proper quality. It is the province of the industrial and efficiency engineer to help guide the manufacturer as to how far he should go into a question of this kind.

A factory with an undersold output is no place for a premium or bonus system. Accurate and simple accounting and routing are requisites here. With an oversold output, a premium, bonus or piece rate system, based on accurate time study, combined with accurate and simple accounting and routing are necessary to produce the maximum efficiency on the shop end, combined with a purchasing, inspection and stock department that can keep pace with a well developed shop organization.

Purchasing. The most effective coöperation between the factory and purchasing departments is as essential as time study or production engineering work. Of what avail is time study

and intensified production if the materials the purchasing agent buys at the lowest price will not meet the requirements of the product in quality? Work will either be thrown away before it is assembled, or if sent out in the finished product, it will react on business. The only way is to buy to specifications and see that the material is on hand before it is needed and that the specifications are conformed to.

Low prices paid for materials are not necessarily exponents of a purchasing agent's efficiency. The man who can discriminate and buy the right thing at a fair price is the kind of man that lasts in this period of competition and exacting requirements.

Serious delays and expenses are often caused by incomplete or incorrect specifications for simple materials and supplies. This trouble can be obviated by a symbol or number system which ties all materials used in the factory to a standard specification which is definite and complete in its wording.

Engineering. A product improperly designed and well made cannot maintain its place in the market, and, conversely, a product properly designed and improperly made, cannot be sold. To design properly and to see that it is properly made, is the measure of efficiency of the engineering department.

Proper strength, lines, proportions, tolerations, inspection, instructions, manufacturing specifications, tool design and manufacturing, should be done in this department and done thoroughly. Time study and bonus system are thrown away if done on work that cannot be used, or hurts trade. Further, responsibility is more readily placed if this is done in the full sense and meaning of the word "complete."

The engineering department in the modern organization of high efficiency is the most important of all, as it is the fountain head from which all specifications are issued, designs made and quality of work determined.

Inspection. To assure proper materials being given to the workmen is the first and most important duty of the inspection department, followed by proper tools, condition of machines, jigs and fixtures to assure reasonable performance of acceptable work. These functions are just as necessary to efficient work as time study or bonus system, for without these the intensified production would be lacking, owing to the fact that conditions for perfecting the work would not be constant and the failure

to perfect such work would be beyond the workman's control.

After these requirements have been brought up to the proper standard of efficiency, this division can control the quality of the work as specified by the engineering division and is in a position to insist on its quality being maintained.

Maintenance. To do a full day's work a man must have proper light, heat, power machines, tools and fixtures, etc., in proper working condition, and it is up to the management to see to it that he does. One of the most common troubles is the condition of belts, long ago recognized by Fred. W. Taylor and covered in his paper on Shop Management.[1] His system with the belt, bench and scales in a factory using many belts is the best obtainable and shows direct results in volume of output and saving in belt bills.

Countershafts, main shafts, jack shafts, motors, machine repairs, should receive a systematic supervision to insure constant and efficient operation. It is true that time study develops these requirements, but these requirements should be attended to first or time study will in a way be wasted.

Accounting. To have reasonably accurate costs is both desirable and necessary, not only as a means of efficiency but also to eliminate unprofitable articles of manufacture and produce the more profitable ones. This system requires methods of factory accounting which interlock with routing system, time keeping, and stores, requiring a close coöperation with the stores, inspection and producing work of management.

Proper distribution of overhead charges, accurate time study and charges, accurate material charges, controlled from a central point in which all is charged against its proper account by the same mental interpretation is the only accurate way, combined with a symbol method, not too complicated, which places the burdens where they belong at the time the expense is incurred.

Stores. Raw and worked materials must be properly accounted for, and the truthful conduct of a stock room is important and necessary. Stores records should be complete and show enough information to gage efficiency without being so complicated and cumbersome as to require more time to tell the story than an inventory.

Maximums and minimums should be so proportioned as to allow a minimum amount of capital being tied up in fixtures,

[1] Trans. Am. Soc. M. E. vol. 24, p. 1337

stock, raw materials and work in process as well as all materials spoiled or defective. A graveyard in a store in plain sight of all is a mighty object lesson to the management and workmen.

The broad or commercial interpretation of efficiency engineering, or scientific management, is profitable management, in which the final measure of success is the return on the investment. As this return is dependent on other than labor elements, it would seem but fair that we carefully and earnestly consider the fact

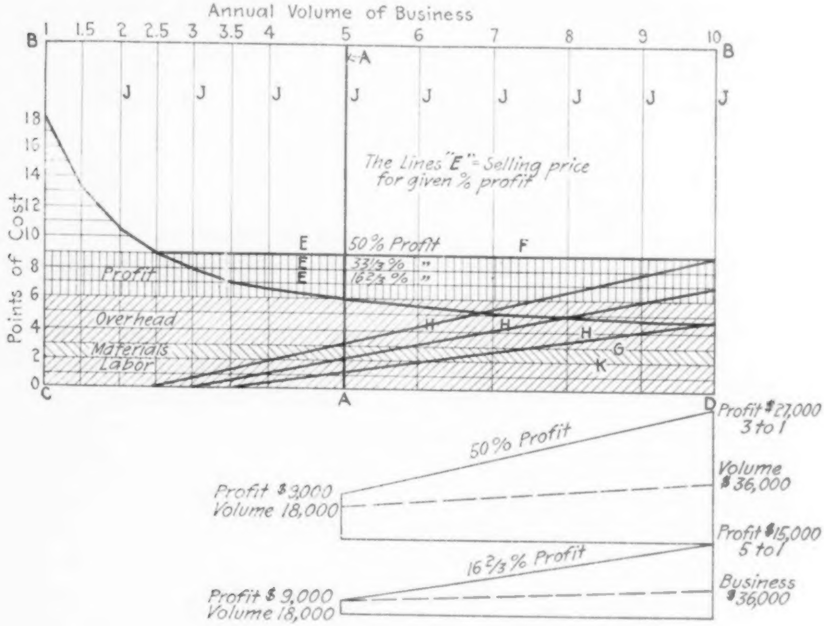


FIG. 17 DIAGRAM FOR DETERMINING COST OF LABOR, MATERIALS, OVERHEAD AND PROFIT

that no man can do efficient work at a machine unless the conditions are made right for the performance of such work and that each function of the industrial organization requires as close, if not closer, attention on the part of the management than do the workman and the machine.

Explanation of Diagram. Variations in expense and cost of labor and materials are practically negligible, but each factory or unit of output should have a separate diagram based on actual conditions of costs of flat labor, materials, overhead and profit.

In Fig. 17 *BC* shows the points of cost; *BD* the points of profit; the different percentages of profit are shown by *EE*.

To use the diagram, assume first that the product is sold at a certain price. Then select *E* to correspond to the profit for these price points. Following this line to the left until it intersects the curve, will give the point where the year's business will break even. To illustrate with 50 per cent profit, it will be necessary to do a business of 2.5 per year in order to break even. On an annual business of 5, the profit would be 3. With an annual business of 10, the profit would be 9. Then the dollars and cents profits would be those made on 5 multiplied by 9 and divided by 3.

The line *HH* is drawn from the point of no profit to the point of maximum profit on the basis of 10 for the year's business, or double the average business.

For any given volume of business of the line *BB*, the points profit could be obtained by the intersection of the lines *JJ* with the line *H* and read out to the scale on the line *BD*.

By studying Fig. 17, it will be seen that the cost of materials and the overhead expenses are so great in proportion to the labor performed that more emphasis should be placed in this report on the management end of the factory than on the workman and the machine.

Fred. W. Taylor. The preparation of this report has evidently involved careful research, followed by a close analysis of the materials gathered in. The viewpoint from which the whole subject is examined is new and original. Most writers upon this subject have emphasized the necessity of reducing to a science the knowledge which in the past has been in the heads of the workmen. The change from rule of thumb to scientific knowledge has been largely dwelt upon, and its importance pointed out. The thought of the committee, however, centers mainly about transfering this knowledge to the workman after it has been acquired by the management; and from this viewpoint scientific management is very properly summarized as "the mental attitude that consciously applies the transference of skill to all of the activities of the industry."

The Committee very properly calls attention to the significance of the change in the mental attitude of both sides which takes place under scientific management. This would seem to be the most vital element in scientific management. It was,

indeed, looked upon as of such importance that, during the hearings before the House Committee "to Investigate the Taylor and other systems of management," man after man came from the shops which are being run under scientific management, to testify that the very essence of this system lies in the great mental change which comes both to the management and to the workmen. In fact, with but few exceptions, these men testified that without this complete mental revolution, scientific management could not exist.

This mental change is great and far-reaching. It means essentially a change from suspicious watchfulness and antagonism and frequently open enmity, between the two sides, to that of friendship, hearty good-will and coöperation. It means a change from the old belief that the interests of employer and employe are in many respects necessarily antagonistic, to the firm conviction that the true interests of the two are mutual.

This feature of scientific management is of such importance that it seems desirable to make one of the causes for the change in mental attitude a little more clear. The following illustration may help to do this:

Into the manufacture of any article there enter two items of expense, the cost of the materials of which it is composed, and the cost of what are commonly called "overhead expenses" or general expenses, such as the proper share of power, light, heat, salaries of officers, etc.

Now, if these two items of expense, cost of materials and general expense, be added together and their sum subtracted from the selling price of the article, we have what is called the "surplus." And it is over the division of this surplus between the company and the men that most of the labor troubles and disputes have come in the past. The men want as large a part of this surplus as possible in the form of wages, and the company as large a share as possible in the form of profits. And in the division of the surplus, under the older systems of management, both sides have come in many cases to look upon their interests as truly antagonistic.

A part of the great mental revolution that occurs under scientific management is the complete change in viewpoint of both sides as to this surplus; from looking upon the *division* of the surplus as the important question, they both come to realize that if, instead of pulling apart and quarreling over it, they join

together and both push hard in the same direction, they can make this surplus so large that there is no need to quarrel over its division, because each side can get a far larger sum than they had ever hoped to get in the past. And each side realizes that this result would have been entirely impossible without the hearty coöperation of the other. The workmen see clearly that without the constant help and guidance of those on the management side, they could not possibly earn their extra high wages, and the management see that without the true friendship of the workmen their efforts would be futile, and they are glad to have their workmen earn much higher wages than they can get elsewhere.

The introduction of scientific management is, so far as I know, the first large movement in industrial history in which a great increase in the output of the workmen has been at once accompanied by a large increase in the earnings of the workmen. The great increase in output resulting from the introduction of labor-saving machinery was not at once accompanied by much if any increase in the wages of operatives, and in many instances the introduction of labor-saving machinery resulted in paying lower wages to the operatives of these machines than had been received by similar hand workers before the introduction of machinery. The main profit was absorbed at first in almost all cases by the manufacturers, who introduced the new labor-saving machinery. In the end, of course, the operatives, along with all the rest of the world, have profited immensely through the introduction of labor-saving machinery.

One of the most notable features of scientific management, however, is that the group of men who have introduced it have insisted that the workmen coming under its principles should at once be paid from 30 per cent to 100 per cent higher wages than they could get elsewhere. This fact is not appreciated by the general public, and largely because the labor leaders, consistent in their fight against the introduction of any labor-saving device, have seen fit to misrepresent far and wide almost all of the good features of this system; and in doing this they have strenuously denied that the workmen coming under scientific management are paid higher wages than heretofore. Quotations such as the following, taken from the famous circular distributed by President O'Connell throughout the Machinists' Union, are typical of this misrepresentation by labor leaders:

Wherever this system has been tried it has resulted either in labor trouble and failure to install the system, or it has destroyed the labor organization and reduced the men to virtual slavery and *low wages*, and has engendered such an air of suspicion among the men that each man regards every other man as a possible traitor and spy.

The installation of the Taylor system throughout the country means one of two things—i. e., either the machinists will succeed in destroying the usefulness of this system through resistance, or it will mean the wiping out of our trade and organization with the accompanying low wages, life-destroying hard work, long hours, and intolerable conditions generally.

In answer to this statement of O'Connell's, however, in the sworn testimony given before the House Committee to investigate the Taylor and other Systems of Management there was presented a schedule of the present wages in comparison with the past wages of all of the workmen who had been more than 12 months in the employ of a company which was using scientific management. This statement showed that the workmen were then receiving on an average 73 per cent higher wages than when they first came under scientific management. The list of employes included all kinds, even the colored men who helped move the materials around the floor of the shop, and the sweepers, etc.

The testimony also showed that the company, after paying this 73 per cent increase in wages, found itself better off than it was under the older type of management. That fewer workmen were turning out three times the output formerly obtained and that the selling price of machines manufactured had been reduced 25 per cent.

It is object lessons of this sort which are rapidly convincing those who investigate scientific management that the interests of both sides are mutual, instead of antagonistic.

The historical portion of the report shows careful study, and is evidently the result of much research. In certain particulars, however, it is somewhat misleading; that portion of it, at least, which includes the quotations from Adam Smith, etc., and particularly Tables 1 and 2, given in the Appendix.

Although the fact is not specifically stated, still the general impression from reading this part of the report is that "time study," which is the foundation for "the transference of skill from the management to the men," was practically carried on in 1760 and in 1830, as it is now under scientific management. This is, however, far from the truth, and in the interest of his-

torical accuracy it may be desirable to make a statement as to the beginning of "time study," although I realize that questions as to who started time study, and when it was started, are of very little consequence, the important questions being, what is time study? and, how shall we make it more useful?

Time study was begun in the machine shop of the Midvale Steel Company in 1881, and was used during the next two years sufficiently to prove its success. In 1883, Mr. Emlen Hare Miller was employed to devote his whole time to "time study," and he worked steadily at this job for two years, using blanks similar to that shown in Par. 367 of "Shop Management."[1] He was the first man to make "time study" his profession.

It is true that the form of Tables 1 and 2, given in the Appendix to the Committee's report, is similar to that of the blanks recording time study, but here the resemblance ceases. Each line in Table 2, for instance, gives statistics regarding the average of the entire work of an operative who works day in and day out, in running a machine engaged in the manufacture of pins. This table involves no study whatever of the movements of a man, nor of the time in which his movements *should* have been made. Mere statistics as to the time which a man takes to do a given piece of work do not constitute "time study." "Time study," as its name implies, involves a careful study of the time in which work *ought* to be done. In but very few cases is it the time in which the work actually was done.

Previous to the development of "time study" in the Midvale Steel Works, there have in all probability been many instances in which men have carefully studied and analyzed the movements of other men, and have timed them with watches. (No such instances have, however, come to my personal attention.) Any such former work was without doubt confined to isolated cases, and was of short duration; and (most important from the historical point of view) it did not lead to the development of a new trade, or, more properly, to a new scientific occupation, "the profession of time study."

Any former efforts of this kind would bear the same general relation to the time study done in the Midvale Steel Works that the many early attempts at flying bear to the work of the Wright brothers.

The Wright brothers started "man flying."

[1] F. W. Taylor, Trans. Am. Soc. M. E., vol. 24, p. 1436.

The Midvale Steel Works started the "profession of time study."

(I do not of course intimate that the two developments are of equal importance.)

Time study is the one element in scientific management beyond all others making possible the "transfer of skill from management to men." The nature of time study, however, is but imperfectly understood and it is therefore important to define it clearly. "Time study" consists of two broad divisions, first, analytical work, and second, constructive work.

The analytical work of time study is as follows:

a Divide the work of a man performing any job into simple elementary movements.

b Pick out all useless movements and discard them.

c Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade.

d Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.[1]

e Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

f Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

g Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

[1] Recording these movements so that they can be readily found is the most difficult element of time study. The writer threw away his first two years of time study because it was so poorly indexed that he was unable to find the elements when he needed them.

h Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

i From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

k The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.

It is unusual to make a study such as this of the elementary movements of the workmen in a trade. The instances in which this has been done are still rare[1]: And it would seem that this must be due to a lack of appreciation of the great power which is given to the man who possesses a knowledge of the time value of these elements, and also to a lack of appreciation of the large variety of work to which these elements apply. How many men, for instance, know that a man who has received his education in "time study" through analyzing their elements of the movements of machinists engaged in manufacturing conveying and hoisting machinery, can go with this knowledge into another establishment manufacturing machinery not in the most remote degree resembling hoisting machinery, and there use this knowledge to fix accurate daily tasks for the machinists? Yet during the past year and more, a young man trained in time study in the Link-Belt Works in Philadelphia, has been setting the daily tasks in one of our arsenals manufacturing a large variety of

[1] Most of the men who have made what they call "time study" have been contented with getting the gross time of a whole cycle of operations necessary to do a particular piece of work, and at best they have thrown out the time when the workman was idle, or evidently purposely going slowly.

war materials, including the great disappearing gun carriages used in our coast defence.

Surely, when the significance of such a fact as this is appreciated, companies employing machinists, even though they may be manufacturing radically different kinds of work, will join together in studying the rudimentary elements of the machinists' trade and then in publishing this knowledge so that it may be available for hundreds of companies, where now it is the private property of the few concerns who have had the patience and the courage to be pioneers in this field. It is the lack of published data regarding the time required to perform each one of the elementary operations in our various trades (more than any other element) that makes the introduction of scientific management such a slow process.

If we accept the committee's definition of the new management as the "transference of skill from the management to the men," it is evident that the management cannot transfer knowledge and skill until they themselves possess this knowledge, and up to this time each new company introducing scientific management has been obliged to obtain this rudimentary knowledge through their own analysis and study, a very slow and tedious process.

Seventeen years ago, I predicted, in a paper read before this Society,[1] that books would be published similar to our engineering handbooks, embodying a time study of all of the elementary operations occurring in our various trades; and, was then greatly laughed and sneered at for making this statement. Only one such book has as yet appeared, but I wish to repeat my prophecy with more emphasis even than before—that hundreds of books of this sort will be published in the future, and in the not far distant future. These books will make possible "the transference of knowledge and skill from the management to the workman" on a large scale throughout the country, and the introduction of scientific management will then indeed proceed at a rapid pace.

F. G. Coburn[1] said that the committee have expressed in their report the "human interest" side of scientific or labor-saving management, which some of its critics say it lacks. The human part of industrial management, it seemed to him, was

[1] A Piece-Rate System, Trans. Am. Soc. M. E., vol. 17, p. 856.

the use of certain psychological or psychic influences to cause employes to work hard, loyally and intelligently, and the degree of success attained depended largely on the number of these influences that were correctly used. They have never been clearly defined and are not clearly understood, even by those who use them. When they are defined, the industrial manager will have a set of proximate rules for a game which is at present played without rules.

The manager who supports his unconscious use of these psychological influences with known methods of labor-saving management, i.e., worked-out details based on the basic and regulative principles stated in the report, applied to his own plant, is bound to be better off than if he did not.

The system of management is but the tool of the manager. Alone it is useless, may even be dangerous; the management without it is handicapped, whereas the system, backed by an active mind continuously using it, is the effective combination. And labor-saving management is a system that forces the executives to manage.

As at present understood, the expressed principles underlying and regulating labor-saving management do not completely solve industrial management. They may only postpone the strike problem. A prominent investigator of business and industrial problems expressed this by saying that there is no assurance that the increased reward offered to the worker for attaining high production is the worker's correct share of the increased profit. He has his own misgiving as to what would happen were the greater part of a given labor market employed under labor-saving management.

It would seem that coöperation between employer and employes, so necessary to the successful practice of labor-saving management, is based on a bargain subject to change; and that successful readjustment of the bargain would be required from time to time, to insure the continuance of such coöperation. This may settle itself. A noteworthy example of readjustment initiated by the employer in favor of the employes has been recently brought to his attention. He expressed the opinion that the committee's report opened the way to study of psychological principles—or psychic, perhaps—that are involved; and the hope that some day may see a committee of this Society appointed to take up this investigation.

Carl G. Barth. I am gratified with the report as an endorsement of the kind of work I am permanently engaged in; particularly as I find among the names of the members of the committee who have signed the majority report, that of a personal friend who, only through this investigation has become a convert to scientific management. I am unable to take as broad a view of the matter as the committee have attempted, as I am tied down too closely to the daily details and difficulties of the practical introduction of scientific management to devote much time to its broad historical and economic aspects. Part of the report, also, has a rather amusing side for those of us who now for several years past have been working with some success in this field, in that it is virtually a declaration to the effect that the committee has assured itself that there really is such a thing as "scientific management," and that it does accomplish some of the things, at least, which its exponents allege that it does. It reminds me of the farmer who came to town in the early days of the automobile to assure himself that there really was such a thing as a horseless wagon not requiring tracks to run on, and that it actually did carry people around in the streets without running wild and upsetting everything in its way, except when in the hands of a driver possessing more ambition than experience and sense of responsibility.

As regards the minority report, I see no good reason for its coming into being, as it contains nothing that I cannot agree to, and to my mind nothing that it recommends conflicts with the majority report.

It merely asserts that there are places in which, and conditions under which, the introduction of scientific management would not be a paying proposition; a matter that I do not believe anybody will dispute. In fact, experience has long ago taught me that there is hardly an establishment in which there is not some department or corner of the works which is not better left almost untouched by the new order of things, except in the matter of having its relations to the rest of the works properly dovetailed into this.

To take the automobile for a second illustration, I have never heard of anybody recommending its use to the extent of declaring that walking is no longer a profitable and sensible method of locomotion, to be eventually given up entirely; though we also know that some automobile enthusiasts do use the automo-

bile at times and in places where walking would be more appropriate.

As regards the attempt of the committee, and others, to give a more appropriate name to what we all now pretty well understand by scientific management, I like to state that I have until recently preferred to refer to what I am trying to do, as the "Taylor system of management;" and that Mr. Taylor himself was the first one to discourage me in thus using his personal name in that connection, and to suggest substituting therefor the term scientific management. However, as I am not only not ashamed of, but on the other hand exceedingly proud of, being accused of being Mr. Taylor's most orthodox disciple, I have stuck to the former until recently; though since numerous imitators have invented a number of substitute names, so far as I can see to no practical purpose, I have become more favorably inclined to the use of the term scientific management. Accordingly, I now refer to myself as an exponent of the "Taylor system of scientific management," and feel that in doing so I have just about the whole thing.

In his discussion Mr. Gillette tries to point out that Mr. Taylor and his disciples have not covered the whole field and mentions as an example, cost and accounting as a matter to which they have paid no attention. However, the mere fact that Mr. Taylor has not written on every subject of his activities, must not be taken as a proof that he has neglected any important matter connected with the management of an industrial institution. The fact is that Mr. Taylor's disciples also owe him a great debt for the cost and accounting system he has handed over to them, one which for completeness and flexibility stands absolutely unequalled even today, in spite of the great attention this subject has recently received.

Mr. Church also mentions that the study of machines is a matter thus neglected. However, this is also a subject Mr. Taylor gave serious attention over 25 years ago, or about the same time that he first took up the study of the art of cutting metals, and this has played one of the most important roles in the subsequent work done by myself in the perfection of some of Mr. Taylor's methods.

Again, one speaker suggested that there should be a special purchasing agent for buying labor, as if that too were a brand new idea, whereas Mr. Taylor has also pointed out the desirabil-

ity of that, and as long ago as 1895 gave us an example of it in a man employed by some Western company at a salary of $5,000 a year, who had the buying of labor down to a fine art.

Mr. Gantt has told us about the disastrous results of changing to piecework from his bonus system of paying, in a plant systematized by himself, and I fear that what he said might have been misleading to some of the audience.

There is no question that piecework based on careful time study is the best and most just form of contract between employer and employe, and though I have not introduced Mr. Taylor's differential piece rates for some years past, I still believe that system is the best suggested to date. However, it is so difficult to get employers to wait until all such standards have been provided, and such time-study men have been trained, as are absolutely essential for the introduction of a piece-rate system, that we are usually forced by circumstances to beg the question and to resort to the expedient of a bonus or premium system.

These systems have the advantage of any piece-rate system, and particularly the differential, in that they may be established and give some satisfaction to both parties concerned, long before it would be possible to make a success of a piece-rate system.

However, there is no doubt in my mind, that the differential piece-rate system conceived and used by Mr. Taylor some 30 years ago, is the ideal of all the schemes suggested to date for paying workers in any other way than by straight day wages.

Regarding the use of a moving picture machine for motion- and time-studies, it looks to me to be practically the same thing as was offered to the Watertown Arsenal at the time we took up that part of the work there. I do not remember the inventor's name, only that he was connected with the Navy or with one of the navy yards in one capacity or another. While the scheme was interesting, it was declined after a conference between the commanding officer Mr. Merrick, and myself, particularly on the opinion expressed by Mr. Merrick, who is one of the most experienced time-study men in the country, and because of the anticipated great expense both of procuring and operating such a machine. Perhaps this was a mistake, for no doubt the machine can be successfully used for motion study, and hence for the elimination of useless motions, but I am still open to conviction regarding the use of any machinery of this kind in connection with time study. The two main difficulties in time

study are: first, to judge when a worker is working at a proper rate and to make proper allowances when he is not; second, to make proper allowances for necessary rests, etc.; and I do not see how any kind of machinery can help us in these difficulties.

ALEX. C. HUMPHREYS. We should discuss frankly the questions that come before us. Professor Thompson in his remarks made this statement: "Referring to the problem of wages, the solution of this problem, if there is one, is not to be looked for from engineers. When an engineer wanders into the field of economics he is apt to bring about the same diverting spectacle that the economist would who would undertake to expound the principles of machine design."

I think that this statement should be met in a meeting of this kind, not in the interest of the engineer so much as in the interest of truth; and certainly so in this particular meeting which is called to consider the subject of efficiency in management. This day's work alone, I think, should be sufficient to contradict effectively the statement to which I object. Again, the record of our industrial life, largely directed and controlled by engineers, serves to contradict the statement. A book economist makes his principal error, and, in my opinion, he has many to answer for in this country especially to-day, in neglecting to consider facts developed in the field of work and so in failing to look on all sides of the question, as necessarily, in my opinion, any man must look; particularly one who is primarily a book man. Unquestionably, the book economist fails in this regard because he is not qualified by practical experience to arrive at exact conclusions.

Finally, after giving this matter very serious consideration for a number of years and having had, I believe, unusual opportunities to judge through my work as an engineer, an industrial manager, and the president of an engineering college, I do not hesitate to say that some of the most inefficient guides as to questions of economics are certain of the professors of economics in our colleges and universities. I trust that Professor Thompson will believe that in this nothing personal is intended.

DAVID VAN ALSTYNE[1] in a communication endorsed the minority report of Mr. Vaughan. Referring to Par. 1*a*, he said that while it may be possible that the application of the newly dis-

[1] 105 West 40th St., New York.

covered principles of management to railroads would result in a million dollars a day economy such a statement has no practical value because the application of these principles is impossible at present and will be for many years. The investment required to make possible such economy would be enormous and the change of attitude on the part of railroad owners, operators and employes before such investments and changes in methods are possible will be long deferred.

Referring to Par. 1*c*, any system of management which cannot be made acceptable to organized labor is doomed to failure. There is probably no greater problem before scientific managers than to convince labor unions that scientific management has advantages for them as well as for employers.

The term scientific management seems inappropriate because it tends to emphasize the contrast between a system presumed to be based entirely on scientific principles and one in which presumably nothing is done scientifically. Neither wholly scientific nor wholly unscientific management exists and the degree to which management is scientific is the extent to which it endeavors to know what its conditions are, what they should be and how to bring the actual to the standard.

Hugo Diemer. The report of the committee indicates that in their opinion there is no system of management any more than there is a system of music, chemistry or education.

The committee is to be commended for a strong effort put forth to get at the fundamentals. It should be borne in mind, however, that it is possible to go to extremes in our search for basic principles. For instance, we might consider that the basic principle of mathematics is measurement. If we contented ourselves with this bald statement we would not explain the scope and objects of the science of mathematics as fully as if we extended our definition somewhat.

I believe we should not content ourselves with saying that the principle of division of labor is the basis of manufacturing. If we add to this statement a further one that the principle of division of labor gives rise to such matters as organization, control, specialization and functionalization, we are adding to our definition the sort of matter which we would consider it necessary to add to our definition of the basic principle of mathematics.

Attention is called by the committee to the fact that early writers foreshadowed the planning department, also that motion and time study are not even 19th century products, but that they were known

and practiced at the opening of the manufacturing era in the eighteenth century.

The relationship of these isolated cases to the modern science of management is not much more definite than Jules Verne's prediction of the submarine and the aeroplane to the modern perfection and utilization of these ideas. Even in King Solomon's time we had pretty well regulated subdivision of labor, also the eight-hour day with Saturday half holiday and pay checks.

There is no present day science that was not foreshadowed by disconnected parts in earlier centuries. For this reason I would change the definition which the committee has given for the second basic principle, which they designate as the transference of skill. The committee illustrate as examples of this principle the transference of the skill of the inventor to the power-driven mechanism, also the transference of the skill of the real expert in management who trains and directs the persons who are permanently to manage. I believe this element can be better defined by stating that it is the conscious application of scientific methods to all phases of industry, or the conscious effort to build up a science of industrial management. The real science of management will apply research methods, not only to designing and testing but to all phases of industry.

Henry P. Kendall[1] outlined the experiments which have been worked out by the company with which he is connected, in the purchasing of labor, and spoke of the work of the employment man as a particular function in scientific management.

In this establishment this man engages the employes and tries to apply to them whatever physiological test he can to determine the kind of work each is best fitted for, or whether any particular one is fitted for the position for which he applies.

In employing women and girls, all are hired subject to the approval of the factory nurse, and if there is any question as to the health of men applicants, they are likewise passed upon.

So far as any person can judge, employes are given the kind of work for which they are best fitted.

The employment man's responsibility does not cease when he has hired the man. He has to follow his record in his work, and adopting a suggestion that came from James M. Dodge, cards are used to preserve the record of each employe. Four times a year information on each employe is added to these cards, as to how he is performing his work, his aptitude for it,

[1] Plimpton Press, Norwood, Mass.

his skill and earning power, and general deportment. He keeps in touch with each foreman or gang boss, and gets a signed report on each employe for these card entries.

The hiring and discharging and matters of discipline of the factory are all concentrated in the employment man, which prevents the injustice that comes from a gang boss or foreman discharging a man in a moment of anger and saying that he is no good. Should he say that a man was no good, and recommend his discharge, a written report from several quarters might contradict the statement, if it were unjustly made.

The training of young workers is especially important. There is nothing so discouraging to a boy as to be set to work at the end of school by an average foreman and forgotten. He may be in the wrong place and not fitted for that kind of work. He has, in the employment man, one to whom he can go for advice in regard to his present employment, for suggestions in regard to outside education or instruction, one who is in sympathy with him, and with whom he can rest his grievances and feel secure that he will not get in wrong with the boss.

The foremen at first thought they would lose their authority when they could no longer hire and discharge, but now they feel that it rather helps their authority to have the employment man to send to in cases of discipline. When a man is discharged by a foreman, although perhaps for cause, this may be done in an angry manner, and he may leave defiant, and with a determination to "get even." If instead, he is called to the office of the employment man and an explanation is given him as to why his services have not been satisfactory, and he is made to see that he is at fault, and if this is done in a quiet frank way, he leaves with an entirely different feeling. Under this present scheme, the employe is given an opportunity to register just complaints against a foreman, if he has any.

The purchase of machines and equipment has been strongly emphasized. The purchase of labor is more important, but is given less attention. Then, too, the main functions of scientific management can be used only in combination with other functions. This function can be adopted in any concern with equal advantage.

Tracy Lyon suggested that if there is any lack in the report it is in the consideration of the reasons for the vigorous opposi-

tion to the new element of management which is mentioned and the absence of permanent results from some conspicuous efforts in this direction. The subject of so-called scientific management is often clothed in glittering generalities which offer no practical suggestions to the average man, but it really means no more than that the manufacturer, operator or business man shall take the time or employ others to consider analytically every condition of his business and every step in his operations rather than to push ahead by mere force of weight. Looked at in this light it would seem that any real opposition to the "new element" must be to the form rather than to the substance and to ill-advised and hasty efforts of "systematizers" in name only. We have yet to discover any royal road leading to efficient management other than through painstaking and persistent effort.

It is difficult to understand a charge, that if a manufacturer's tools are put in the best operative condition and so arranged as to minimize the movement of material, if provision is made for material in definite and sufficient quantities, small tools and other necessities are on hand before the commencement of a piece of work, and a liberal and intelligent measure established for the payment of the workman, the result will not be to the benefit of the employer, the employe and the consumer. The function of a planning system is no more than to provide in advance that the right thing shall be in the right place at the right time, and to distribute the work to the proper tools in such lots that twelve men will not be nursing their jobs with a small amount of material ahead of them, when there is not more than six can take care of. It does not seem as though such a provision could do otherwise than reduce the cost to the consumer.

Any plan of wage payment can be used whether bonus, piece or day work without interfering with the principles of scientific management, provided there is a clear understanding that the employers are willing to pay liberally for a fair day's work. Some of the systems may have been handicapped by the effort to convey instructions to the workmen in too elaborate a manner. The prime requisite is that time study men and instructors should be thoroughly practical and experienced.

Dexter S. Kimball. Ever since the beginning of the present industrial era there has been a growing tendency to separate mental and manual processes and to again subdivide these by

the application of the division of labor. The engineering and drafting department was the first direct result and is the best existing example of the separation of the mental from the manual. While the art of industrial management has lagged behind scientific design for natural reasons, its fundamentals are well known and basic data will no doubt soon be available so that we may expect to see it on a more scientific basis.

It is to be noted that the process of "functionalizing" any branch of industry involves no new principle. It is an extension of the general tendency to separate mental and manual processes and motion and time study are not new discoveries as the report clearly points out; but this should detract in no way from the credit due those who have so ably called our attention to the possibility of their more extended use. The ultimate extent to which these principles will be carried and the rate of progress that they will make will depend, however, not on their inherent value or effectiveness alone, but on the growth of public opinion that permits or demands them.

One phase of the discussion touched on in Pars. 62 and 63 deserves more than passing thought. Changed industrial conditions resulting from the separation of the worker from the ownership of his tools have introduced a difficult problem in the matter of the compensation of the employe. The efforts of such men as Halsey and Towne were the first steps toward new methods of rewarding labor. All so called *systems* of management are based on the extension of the principles already mentioned with the addition of some special philosophy of management which invariably includes some variation of these methods of rewarding labor, mixed perhaps, with certain altruistic ideas on the relations between employer and employe and the general uplift of the workman. These altruistic ideas are fine and helpful, though not new, as they were introduced and used by Robert Owen more than a century ago.

Success in the use of these combined methods, whereby better wages and better conditions have accrued to small communities, has led some over ardent advocates of these methods to the hasty conclusion that they really offered a solution of the industrial difficulties which press so heavily upon us. Statements similar to the following are often seen:

"The increase in wages which accompanies this type of management will largely eliminate the wage question as a source of dispute."

"The one cure, the only one for the condition which confronts us is to increase the efficiency of the producer."

That is to say increased productive power *necessarily* means increased profits to the actual producer. But a diligent search through the literature of efficiency engineering will fail to disclose a single new regulative principle bearing on the equitable distribution of the fruits of industry either between the employer and employe, or between the industry as a whole and the ultimate consumer.

Stripped of all sentiment these new methods are exactly similar in operation to labor saving machinery (Par. 37) and their initial and ultimate effects must be similar. They will enable those who first adopt them to obtain some commercial advantage and to pay better wages than their competitors for a time at least. They will also result, if universally adopted, in a considerable increase of productive power; but they in no way affect the fundamentally inherent advantage which must always accrue to those who control the tools of production. They can in no way affect the principle that knowledge of all kinds tends to become common property and for that reason no labor saving device can forestall competition for any extended time. They can in no way affect the law of supply and demand; and even if all the manufacturers in the country were to adopt these methods at once we should continue to see in many places at the same time, storehouses filled with raw materials, idle factories equipped with the finest tools, and people walking the streets without food or clothes and yet willing to work. Labor saving machinery opened the door to tremendous *possibilities* for humanity far greater in proportion than can ever be promised by labor saving management; but it brought with it no self regulating principle which insured equitable distribution of these advantages; and labor saving management is at best a small extension of a great movement.

It is true that all classes of people have profited by the use of labor saving machinery, the actual producer as much as any, and it also follows that in the long run we shall all profit to some extent by increased productive power. But the industrial problems with which we are now wrestling will all be with us till we have made some changes in the basic principles on which we now distribute the results of our labors.

True, all the new systems lay stress on the "square deal" and

the coöperation of employer and employe, but these are old as mankind and have always been available as a basis of economic justice in common with all other welfare work. But these measures are optional with employer and employe and do not constitute basic principles. They are exceedingly useful and beneficial as they serve as a means of better understanding of the dual difficulty and as a basis of corrective legislation, which after all is a reflection of the sentiment of the community and grows with it. It is neither fair nor wise, however, to attribute powers and advantages to efficiency engineering which it clearly does not possess. I am not sure but what a small readjustment of some other of our economic problems would do as much for us as increased productive power. We need and need badly some *scientific distribution* and we shall be fortunate indeed if some of the reactive influences now at work on our social and industrial organization will offer some help in this direction before the strain becomes unbearable.

R. R. Keely briefly summed up the economy from the application of scientific management through placing the control of production in a central office. By this means customers are prevented from becoming discontented through having an order handled improperly or overlooked, and there is a saving in time in getting out important orders, in the nervous energy of the management, in material through preventing waste, in losses due to ignorance of the actual condition of the plant in the old system, and in labor due to the planning of all work in advance of its performance, and the best workmen are induced to remain through the creating of contentment and the offering of higher pay.

The "mental attitude" in scientific management, to which the committee refer, is new in that the individual and his workplace are considered, instead of the shop as a whole, as a unit. So far as he knew there had never been a planning room for the handling of the entire work of an industry from a central office previous to the introduction of scientific management by Mr. Taylor.

Joseph A. Bursley called attention to the fact that this was the first time the Society had devoted an entire session to the consideration of scientific management. He was particularly

interested in the possibility of applying the principles of this subject to works of educational institutions, especially technical schools, and felt that there was a great field for applying this work in teaching in the engineering schools. The men in the shops connected with the universities, for instance, should be shown the best way of doing each particular piece of work, so that after they are graduated, they may transfer this knowledge to others.

This same scheme could be followed in the laboratories where various tests are made; and even in the class room in the solution of problems of various kinds there is always one way which is the best, requires the least time, and gives the smallest opportunity for mistake.

William Kent. I hesitate to criticize so splendid a report, but I do object to the statement in Par. 37, "The expression 'labor-saving management' better conveys the meaning of the movement." Labor-saving management is but a fraction of the new movement. As I conceive it, the whole question is industrial management, and there are three kinds of industrial management, which some one has called, traditional or unsystematized, transitional or systematized, and scientific management. This third type is industrial management carried on in a scientific manner, and it refers not only to labor-saving management, but to saving of fuel, capital, machinery, wear and tear, lubricants, and everything that enters into the product. I think if a scientific expert were called in by the management of a factory and they should say, "We want your services to show us what we ought to do," he would have carte blanche to go into every department as well as the labor-saving department.

In regard to the statement that has been made to the effect that an engineer who dabbles in economics is going outside of his field, I wish to call his attention to the fact that the first paper mentioned in Appendix No. 2 of the paper, No. 207, written in 1886, was on the topic, "The Engineer as an Economist." The engineer was an economist in 1886 and long before that. Part of the education of the engineer, and no small part, is education in economics. The thoroughly educated engineer must be a political economist and when he dabbles in questions of economy, he is right in his own field and is not going outside of it at all.

H. H. VAUGHAN explained his objections to the majority report He differed from the report because it definitely advocates certain things, such as the bonus system, the planning department, functional organization and time studies, as constituting the new way in which to run industrial establishments. No one could value Mr. Taylor's work more than he, but his methods had their limitations like most new discoveries. It is a mistake to think they will revolutionize everything and supersede all other systems.

One thing in the report was very interesting to him, the remarks of James Nasmyth, quoted in Par. 9, in which it is stated: "The characteristic feature of our modern mechanical improvements is the introduction of self-acting tool machinery. What every mechanical workman has now to do and what every boy can do, is not to work himself, but to superintend the beautiful labor of the machine. The whole class of workmen that depend exclusively on their skill is now done away with." He thought that a good instance of how a man's ideas that a new discovery is going to take the place of everything that comes up is frequently limited by his subsequent experience. There are more skilled men in Nasmyth's shop today than there were at the time that Nasmyth wrote these comments.

In his minority report Mr. Vaughan used the phrase, "art of management." There is essentially an art in these things, and one cannot give the rules that make an art. There is more in the creating of a successful shop than the studying of a set of prescribed methods. There must be the peculiar intuitive judgment that comes from experience and from the contact with men.

He said further: "Transference of skill," referred to in the report, means in one place doing away with skill, in another the improvement of skill, and develops into the idea of telling the men how to do everything. It is commercially absurd to assume that we will reach the point where we instruct the men in everything. I believe in experts in the shop, but the experience of the men in the shop must be taken into account. Anybody who has started to build a machine or produce any other class of work with new and unskilled labor, has found to his cost the value of the skillfulness of their men as an asset.

The report advocated functionalizing. Instead, I believe in putting more responsibility upon the foreman, making him the head of the units. Functional management is very much like departmental management on a railroad as opposed to divisional management. The most successful railroads are managed on the divisional system.

We do not expect a divisional man to know everything, but we work through him with the staff department, and want him to be the boss of his unit as far as possible. In that way we certainly get results, quicker action in the case of emergency than where the departmental system is in use and where one must go through a lot of routine to get results. Suppose we have a rush order. One man is put in charge of the job, who follows it through department after department, to see that the work is properly done. We could not do that if each department had to be called upon through its head to coöperate to obtain the results. The best results in our shop have been obtained by putting the work up to the superintendent or foreman and leaving the matter in his hands.

With our piecework system the object is to advise the foreman of what is being done rather than of what has been done. We have obtained good results by putting on a man whose duty it is to advise the foreman from time to time as to what is being done so that he can take immediate action in case any men are failing to make the time expected, as governed by the records in the operation of the shop.

As to the question of fairness in dealing with labor and cutting prices, much of this is really due to the fact that the workmen of today will not stand cutting prices. A few years ago men were less independent and many shops were operated satisfactorily on straight piecework and with cutting prices. There is no use in pretending to be altruistic in this matter. We have been forced to our present position by experience and it is pleasant to know that we can truthfully say to ourselves that it does not pay to cut prices.

We have been building the same class of locomotives for five years under the ordinary piecework system, and by dealing with the men fairly and encouraging them and getting them interested, the hours have dropped from 100 per cent to 68 per cent.

We believe in the piecework system with a guaranteed day rate, and do not use the bonus system, although in my opinion it is better than piecework where the operations are comparatively simple and the conditions standardized. However, the system must appeal to the men, and if they do not understand it the same degree of success will not be secured.

We are using time-study work to a large extent, and I think time studies are of great value in perfecting a shop. On the other hand we had a shop with a pay roll of $4000 a month get into bad conditions. We sent a couple of men there, with a few good demonstra-

tors, picked it right up, and it began to turn out the output. That is better than if we had been depending on a long-drawn-out system; it is a question of personal influence and quick action. The influence exerted in that case will be felt for a long period to come.

As Mr. Gantt has stated, he introduced time studies in our shops, which we value highly. Our results in the time-study work have cost on the average $600 to $800 a month, since we started, and we are now saving $2000 a month on a pay roll of $35,000, contract work. There has been a satisfactory progression with time study, not a revolution; we would not be without it, but, on the whole, it has not been as important as the piecework system.

There is, moreover, certain work in which day work is preferable to piecework. We would not think of putting steam-shovel repairers on piecework. We would rather have them work day work. We must use day work in certain cases and we should then do all we can to help the men to get the results.

We believe that we should not have any more system in our work than we can get along with nicely. We would rather have too little system than too much in the operation of the shop. We think that the best results are secured not only by studying the conditions, but also by studying the men who are operating the shop.

Thomas R. Woolley[1] considered that the benefits from scientific management had not been all that could be desired for the worker, the manufacturer or the consumer. The worker is dissatisfied because of the strain put upon him to increase his speed and the stop watch in particular causes dissatisfaction. If instead of taking the initiative away from the worker, the rule could be reversed and the initiative of the individual encouraged under the guidance of competent executives, the system would have permanent results.

While the manufacturer has been benefited in some cases, in other cases he has been driven into bankruptcy on account of the large overhead burden introduced to carry out effectively the system, particularly where the business fluctuates greatly from year to year and from season to season. Under such circumstances, it is questionable whether it pays to train workers only to let them go during a dull season or to carry them on the pay roll working inefficiently during that period.

Further, the public had not been benefited by the adoption

[1] Efficiency Engineer, Boston, Mass.

of the system and the writer cited a case where a large order for steel was placed, after securing bids from different firms, one of which employed scientific management and whose bid was higher than those of its competitors.

Dealing with Mr. Taylor's example of training men to carry pig iron, he believed that a fraction of the money spent upon labor saving machinery with an electro-magnet in connection with a crane would give better results at less expense.

In considering whether to install scientific management, a manager must determine whether there is enough of one class of work to make it pay him to train men; whether his plant runs continuously throughout the year; whether it will pay to add a corps of men to instruct his workmen; and whether he should consider that it would pay better instead to install the latest improved machinery for the particular class of work to be produced.

Mr. Taylor and his associates are to be commended for stimulating thought along the lines of eliminating movements, etc. Some of these principles can be applied in a plant but all can not be applied in all plants because of varying conditions.

H. K. Hathaway wrote that the essence of this report lay in the phrase (Par. 29), "The mental attitude that consciously applies the transference of skill to all the activities of industry," further qualified by the statement, "the novelty of the new management lies in this transference of skill from the management to the workman.

This viewpoint is so novel that one is led to question whether the older descriptions of the essence of scientific management may not have been wrong. The committee, however, are merely laying emphasis upon one of the elements which has heretofore been looked upon as rather of secondary importance.

Before skill can be transferred, the management must gather in and record the knowledge and skill which were formerly widely diffused in the possession of a great number of workmen, and much of which was an almost unconscious inheritance. Gathering in and systematizing this knowledge ready for use, constitutes the development of a science to replace the old rule-of-thumb knowledge: this is what has been called by other writers the first of the four principles of scientific management, and this point the committee recognize in Par. 47.

The writer's experience leads him to feel that the committee

has not given sufficient prominence to the element of acquisition of skill or "the development of a science" as it has been termed. Such development goes farther than the acquisition of existing skill and results in additions thereto as well as improvement in methods and machinery, and the establishment and maintenance of standards.

It is impossible to transfer skill from the management to the workman first without choosing carefully the workman who is fit to do a particular kind of work, and then training him until he acquires skill: the second of the principles of scientific management. It is not only a transference of skill, but in one sense the creation of skill as well; perhaps a better expression would be the development of latent skill.

The third principle of scientific management has been called "bringing the science and the scientifically selected and trained workman together," which is merely another name for the committee's statement, "the mental attitude that consciously applies the transference of skill to all the activities of industry."

The fourth principle of scientific management has been defined as "an almost equal division of the work and responsibility between the management and the workmen. The management takes over all work for which they are better fitted than the workman, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men." This principle also follows directly the moment the management accept as their duty the first, second and third principles of scientific management. The burden of developing a science where only rule-of-thumb knowledge existed in the past, and the burden of training, teaching and transfering skill from the management to each workman in the place, of necessity calls for an almost equal division of the work between the two sides. So that in the one definition of the new science, by the committee, are implied all of the four principles of scientific management.

It might be proper to point out, in order to avoid misunderstanding, that specialization of workmen on one comparatively simple operation is not necessarily in accord with the best and most economic practice in management. It is a serious mistake and a disadvantage to have operators "unskilled except in a single readily mastered operation" as in the instance cited in Par. 8 of the committee's report. The writer's experience has been that it is not only generally desirable, but in many cases

necessary to economy in manufacture, that each operative become skilled in at least two and generally more of the operations making up a process of manufacture. This is an objection to over-specialization purely from the standpoint of production.

Sanford E. Thompson. Criticism is frequently made of the amount of mechanism required to handle the work of modern management, the number of clerks needed, and the consequent increase in overhead charges, and to a visitor this increase in office is indeed more noticeable than the decrease in number of workmen or the increase in production.

If it were possible in a given establishment simply to make a few time studies and set scientifically accurate rates or tasks so as to obtain maximum production, no objection would be raised to the installation of scientific management, although it is obvious that if such a plan could be arranged, it would have long ago been adopted without resort to laborious study. Yet the criticism is heard so frequently from men of intelligence that it is worth careful consideration.

If we refer to the list of papers selected from the Transactions, and given in the Appendix to the report, it will be seen that those presented earliest discussed methods of setting rates for paying men. Following a short general paper by Mr. Towne in 1886, there are two papers on Profit Sharing, the least intricate form of incentive to the workmen; then from 1890 to 1903, the question of payment is discussed more in detail, the premium plan, piece-rate and bonus systems; then come subjects relating more specifically to the more general problem, the management of the plant. It is evident from these papers that this sequence is not chance, but represents a development, not of theory but of absolute necessity in shop management.

A man who has made studies of workmen and introduced piece rates or tasks on accurate detail time study instead of by the usual "fix and cut" methods, finds that the very requirements of accuracy lead necessarily to standardization of methods. It is necessary to plan out the work of each man, to instruct him in the method so that he may use the least material and accomplish his work in the smallest practicable time, and to install a system of cards and records specially adapted for keeping track of the materials and the time of the men.

The development of what Mr. Taylor terms the mechanism

of scientific management is thus seen. This development indicates that the broad general principles of planning, routing, instruction, scientific analysis, time study and standardization do not represent a mere system for which some other system may be substituted with equally good results, but a plan which is of broad application in management. These things appear to be fundamentally necessary for any organization which proposes to set rates and tasks which will give the men payments based strictly on the actual work which they accomplish, and which will enable them to do the work with the minimum waste of material.

The practical necessity for the introduction of these individual features is very plain to anyone who makes a scientific study of any operation for the purpose of setting tasks.

These statements may be illustrated by one or two examples from actual practice:

Take the trimming of large sheets of paper to make ready for the press. The machine consists simply of a bed plate about 5 ft. sq. at a convenient level above the floor and an adjustable knife running across this bed plate and operated by power. The operator takes the paper, places it on the bed plate, makes the cuts and transfers the paper back to a truck: a very simple operation, lifting paper, cutting, lifting off.

When the work is studied with a view to putting it on the task basis, the following facts are discovered: The cutter is capable of going through a thickness of about 5½ ins. of paper. The size of the paper on the particular machine referred to is large, running up to 40 in. by 60 in. On account of the weight, therefore, the operator has to put it on in several lifts. Since the lift off is easier he is able to take it off in a fewer number of lifts. The number of lifts in both cases is not directly proportional to the weight. It is dependent also on the size, the stiffness, the thickness and the surface finish of the individual sheets of paper. It is readily to be seen, if a man takes six lifts where he should take four, as he naturally will do if he wishes to shirk, the time of lifting and therefore the cost of this part of the work will be 50 per cent too great. It is necessary, therefore, before establishing a task to standardize the plan of furnishing the paper. The paper was always counted, but instead of the usual plan of counting by hundreds, it is now

arranged to divide the piles by slips of paper into individual lifts which a man should take.

For determination of the amount of lift and the other variables, special studies were required. These studies took rather more time and skill than the actual setting of the tasks when this preliminary work was accomplished. After the tasks were finally set and put into operation, it was necessary to throw out of commission the other cutter, which had been working on part time, and the only difficulty experienced was in finding work enough for this one cutter to do. As a result, the cost of the work was reduced 30 per cent with, at the same time, an increase of 40 per cent in the pay of the workman.

This is by no means an exceptional case. It is always necessary first to standardize the machine and the methods. It is this as much as anything else that differentiates scientific from rule-of-thumb methods. Usually the direct results of standardization produce even a greater saving than the actual task and bonus.

Another illustration may be taken from a shoe shop. In the cutting of leather, or in cutting linings from cloth, it is a simple matter to make time studies and determine the time required by the men to pick up the die and make the individual cuts. Piece rates may be easily set, based on the output of each cutter. Suppose, then, that this is done and such rates are set. The men immediately begin to "speed up," but in doing this without any restraint they naturally use more material than is necessary. Now, in the case that the writer has in mind, the raw material used in a certain shop during a week averaged $50,000 in value. The labor cost of cutting this material averaged $280. A 10 per cent reduction in the labor cost amounted to $28, while a 1 per cent reduction in material cost amounted to $50. Instead of gaining money by the setting of rates, the plant would actually lose money, because the men would waste more material. It was necessary, therefore, at the start, before setting any rates to attack the quantity side of the problem, investigate the best plan for layout of dies on the machine and establish some method for fixing the amount of material used by each man. This involved eventually a definite planning of each man's work, so as to show him how to use the minimum amount of material; a routing system, as an absolute requirement, which would properly deliver the materials to him and take away his product; and

a system of instruction and time cards, so as to handle the work in the smoothest manner possible.

It may be claimed that these are special instances which do not often occur, but experience shows them to be very simple cases. Wherever a machine or an operation on construction work is studied thoroughly in order to eliminate unnecessary operations and the waste of materials so far as possible, similar methods must be gone through and a more or less complicated system adopted for the proper handling of the work. Only by such thorough study and investigation can the operation be reduced to a routine which will be essentially automatic.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

The abstracts of articles on agricultural machinery, in particular motor tractors, have attracted so much interest, as evidenced by the inquiries received from readers, that as far as feasible a regular section will be devoted in the Foreign Review to articles dealing with this class of machinery. Arrangements are being made by the Library of the Engineering Societies to secure the most important foreign publications that will be of use in this connection.

THIS MONTH'S ARTICLES

The Odkolek parachute described in the section of Aeronautics is of particular interest, owing to the rapid and apparently reliable action of the apparatus and the fact that it promises protection to the man flying at low altitudes, i. e., just where safe volplaning to the ground is the least possible. In the section Hydraulics a brief note is given on an interesting mathematical investigation of permanent irrotational motion of a heavy liquid in two dimensions, of interest also to the designer of carbureters, because the same equations apply to a certain extent to the flow of fuel through the carbureter opening. The Kromhout heavy oil engine described in the next section, is interesting both on account of its great simplicity and fool-proofness, and because it uses an improved system of hot chamber ignition. In the same section attention is also called to the description of autogenously welded steel cylinders, with their better efficiency, saving of two-thirds in weight of the engine, elimination of pattern costs and scrapped castings, and higher reliability of work turned out. In the Pieper gasoline-electric car a device is described for regulating the fuel supply automatically in such a manner as to make the gas and electric motive units work always in a way to secure the best overall results.

There are several abstracts of interesting articles on pumping machinery, air and water, special mention being here made of the data of tests of water-jet pumps in Germany and description of the Neumann involute pump claimed to eliminate some of the usual power losses and give an efficiency of 78 per cent. In the section

Steam Engineering, articles will be found on the Babcock & Wilcox superheater, tests of Wilton closed ashpit furnaces in Germany, discussion of hollow water-cooled grates, and new German furnace types, while in the next section may be mentioned articles on the testing of balloon cloth, description of apparatus for the determination, even in a small shop, of hardness of materials by the drill test, and emergency methods for testing lubricating oils. Two articles deserve special mention: that of M. Leblanc on the realization of high angular velocities and of M. Jakob on specific heat and specific volume of steam. The first is only partly abstracted in this issue of The Journal, and is of interest not only to the mechanical, but also to the electrical engineer, the latter having already to do with apparatus running at 20,000 r.p.m. and facing the probability of having to employ still higher speed in high frequency alternators for wireless work. M. Jakob takes up the same problem which Professor Goodenough discussed in The Journal for March 1912, from a different point of view. The notice on the exchange of apprentices between manufacturing plants is also worthy of attention, as it appears to solve to a certain extent the problem of allowing a trained apprentice to see something of the world, which a young man is usually anxious to do, and come in the end to his old plant without feeling as if his coming back was due to his failure to get a good job elsewhere. In the German plan, on the contrary, the man comes back when he can say that he is a fully grown up man, and has come home to settle to his life work.

Aeronautics

"Drzewiecki" Aeroplane with Natural Automatic Stability (*L'Aéroplane "Drzewiecki" à stabilité automatique naturelle*, P. James. L'Aérophile, vol. 21, no. 2. p. 26, January 15, 1913. 3 pp., 5 figs. *de*). Description of the Drzewiecki aeroplane and data of some of the tests made for obtaining the data used in its design. It is probably the first aeroplane designed entirely from data obtained in an aeronautical laboratory (the laboratory of Mr. Eiffel, Champs-de-Mars, Paris, France) for that specific purpose. The principle of the natural automatic stability or rather self-stabilization consists in providing the airship with two pairs of planes arranged in tandem and selected in such a manner with respect to profile, dimensions and incidence that the load carrying capacity of one pair of the planes increases and decreases with incidence more rapidly than does that of the other pair of planes, thus producing a couple counteracting any tendency towards perturbations of equilibrium. It necessitates, however, a selection for the second pair of planes of a profile such that the load carrying capacity should vary but slowly with incidence, and the reverse for the other pair of planes, and this in its turn required a series of

preliminary experiments for the determination of the various constants of the planes. The apparatus has not flown yet; but its model, when tested at the Eiffel Laboratory, is said to have shown a remarkable ability to preserve its equilibrium. (For details see *Scientific American*, February 8, 1913, p. 137, and *Scientific American Supplement*, February 8, 1913, p. 89).

A New Parachute for Aviators (*Un nouveau parachute d'aviateur*, *L'Aérophile*, vol. 21, no. 1, p. 12, January 1, 1913. 1½ pp., 4 figs. *d*). The majority of parachutes require a certain height of fall before they unroll and begin to act, which makes them practically useless in case of a fall from comparatively small heights. In the tests of the parachute described below and invented by Mr. d'Odkolek, it opened after a fall of only 2 m (say 6 ft.). The apparatus (Fig. 1) consists essentially of a gun *A* with a

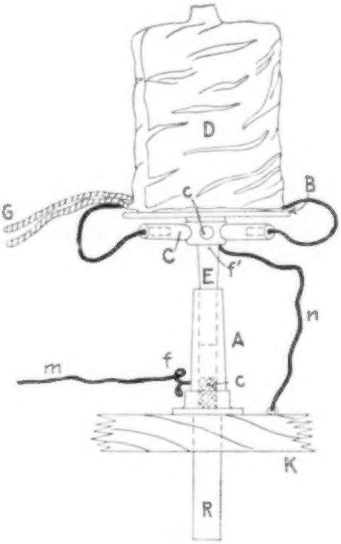


Fig. 1 D'Odkolek Parachute

cartridge at the bottom, and disc *B* over which is placed an arrangement *C* like a three-barrel revolver, and still further above it the furled parachute *D*. The axis of the disc is represented by the steel rod *E* which is also the projectile of the gun *A*. To start the apparatus, the aviator pulls the rope *m* which loosens the trigger *f* which in its turn sets off the cartridge; the same pull on the cord sets off also the cartridge placed in the gun *C*. In the latter case, however, the explosion acts at once on three barrels arranged starwise and having for projectiles three small steel cylinders attached by strings to the sides of the parachute. A very efficient shock absorber takes care of the recoil of the gun *A*. When the aviator pulls on the rope *m*, the explosion in *A* projects the disc *B* which pulls the rope *n* and thus produces an explosion in *C* the latter throwing at angles of 120 deg. to each other three projectiles and thus opening the parachute.

Air Machinery

COMPRESSED AIR LOCOMOTIVE IN MINE WORK (*Die Druckluftlokomotive im Grubenbetrieb*, Hans Wunderlich. *Die Fördertechnik*, vol. 6, no. 1, p. 9. January, 1913. 3 pp., 3 figs. *dh*). General discussion of the use of compressed air locomotives in mines in Europe and the United States.

COMPARATIVE INVESTIGATION OF WATER-JET AIR PUMPS (*Vergleichende Untersuchungen an Wasserstrahl-Luftpumpen*, Grunewald. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, nos. 49 and 50, pp. 1975 and 2011. December 7 and 14, 1912. 17 pp., 35 figs. *cA*). It is hardly possible to build commercially efficient *water-jet air pumps* without experimenting on the testing stand. The problem of the entrance of air between water pistons or water bands is a very complicated one, and many of the theories proposed to elucidate it had to be abandoned after thorough tests to prove them have been made. The first problem of the designer is to drive the water through the pump with as little loss of power as possible: this is so important because the power taken by the water exceeds by far that taken by the air. The greatest losses occur at the place where air mixes with the water, or on the way from the blade wheel to the passages leading to the diffusor and located in the stationary wheel. The tests described in this article have been made with the pumps working on air only; in condenser plant work the pump has also to handle steam which is condensed by the water and lowers the apparent efficiency of the pump. This cannot be shown by figures, but must be borne in mind as one of the advantages of the water-jet pump as compared with dry pumps.

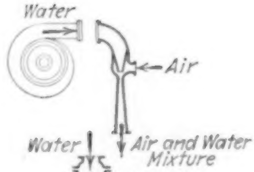
The tests were of a comparative character and had the purpose of determining not only the working capacity of each pump tested, but also its consumption of power per unit of work done. All the air handled by the pumps was measured by the same control nozzles, and the Zeuner and Grashof formula for the determination of the weight of air, in grams per second, was used:

$$G = 397\, q\, F \frac{p'_a}{\sqrt{T_1}}$$

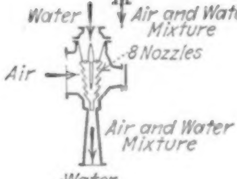
$$G = 0.522\, F \frac{p_a}{\sqrt{T_1}}$$

where G is the weight of air, in grams, flowing through the nozzle per second; F cross-sectional area of the nozzle in qcm; p_a or p'_a pressures in mm mercury in front of the nozzle. The weight of air handled per second is given by Fig. 2B. In determining the efficiency of the pump the author protests against taking into account the air contained in the water and intimately mixed with it. The amount of such air may be quite large, especially when the tank from which the water is taken is small, but this air does not represent useful work done by the pump, and therefore should not be counted.

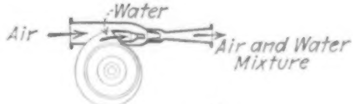
The amount of air in liters (1 liter = 0.03531 cu. ft.) is shown in Fig. 2C. In the neighborhood of the axis of ordinates, i.e. at high vacuums and small nozzle cross-sections, the curves in the figure show a peculiar behavior. When the nozzle is closed, the weight of air sucked in is $G = O$, and



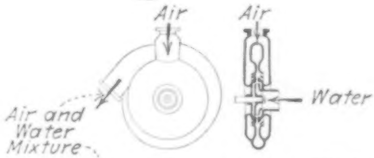
Simple cylindrical water-jet. Pump separate.



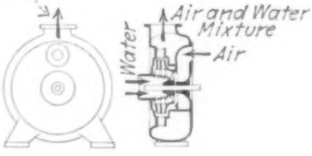
Multiple cylindrical water-jet. Pump separate.



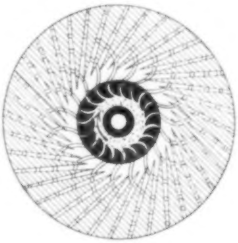
Cylindrical water-jet. Centrifugal pump in one piece with the jet apparatus; full admission.



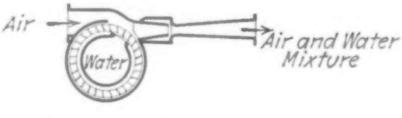
Centrifugal pump with full admission, a very thin disc-shaped water-jet and bladeless wheel; one nozzle wall stationary, the other movable.



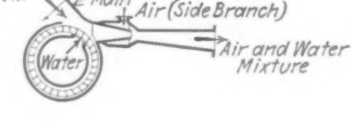
Centrifugal pump with full admission; blade wheel and nozzle ring. Water is taken up by the wheel by suction in many fine jets, and mixes with the air to be sucked before entering into the movable blades.



Centrifugal pump with full admission, and formation of water pistons in the blade wheel. Compression in the stationary wheel.



Centrifugal pump with full admission and formation of water piston in the ejector cone; compression in the diffusor.



Same as the previous type, but with double air drawing off.

therefore the volume of air $V_1 = O$. The curves in the neighborhood of the origin of ordinates cross the axis of abscissae, then rise to some maximum value, not determined, and continue regularly from then on. The curves of Fig. 2C show that with zero nozzle a vacuum is obtained nearly equal to that which corresponds theoretically to the given temperature of water. To indicate the quality of a pump by saying that it can handle so much air per second, and to consider in this only the maximum point on the curve, is misleading, since it is also essential to know how the curve runs in the falling branch, the only one of importance for practical purposes.

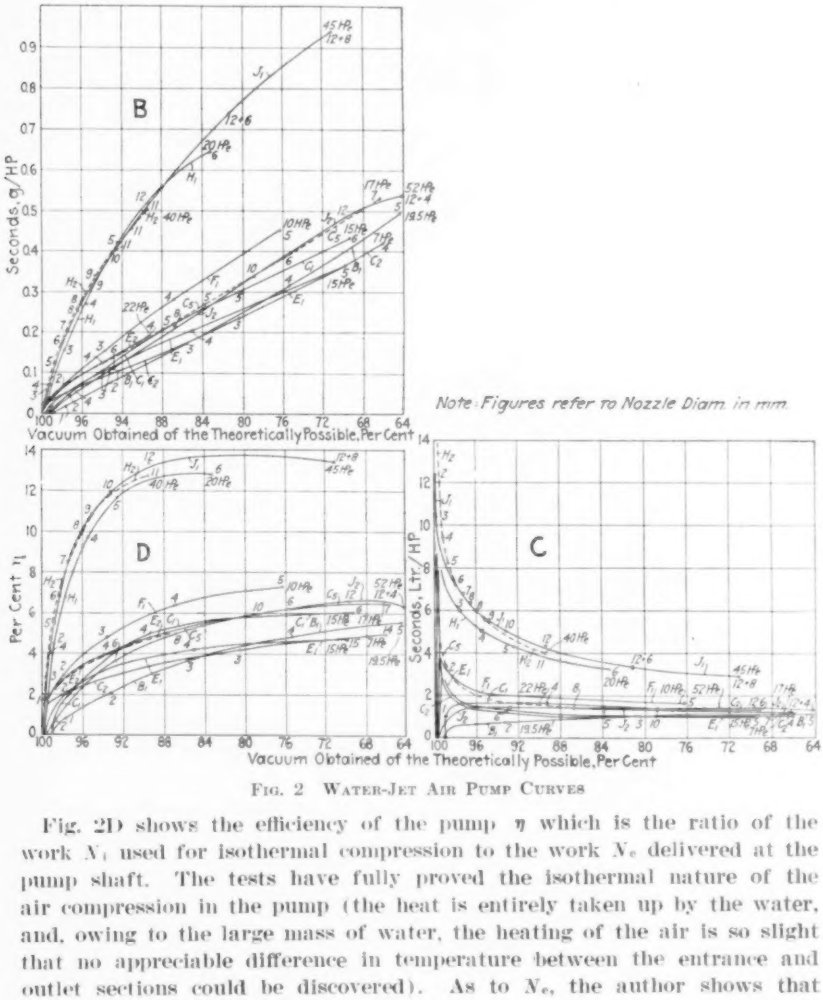


Fig. 2 Water-Jet Air Pump Curves

Fig. 2D shows the efficiency of the pump η which is the ratio of the work N_i used for isothermal compression to the work N_e delivered at the pump shaft. The tests have fully proved the isothermal nature of the air compression in the pump (the heat is entirely taken up by the water, and, owing to the large mass of water, the heating of the air is so slight that no appreciable difference in temperature between the entrance and outlet sections could be discovered). As to N_e, the author shows that the curves representing it as a function of the nozzle area run nearly

vertically, or that the amount of power taken at the pump shaft is practically independent of the nozzle cross-section. In fact some pumps of smaller dimensions show a better efficiency than larger units of the same construction.

The various types of pumps investigated are indicated in Fig. 2A. The original article contains full data of the tests which cannot be reproduced here owing to lack of space.

Hydraulics

ALUMINUM WORKS OF VIGELAND NEAR VENNESLA IN NORWAY (*Die Aluminium-Werke Vigeland bei Vennesla in Norwegen*. G. Wüthrich. *Schweizerische Bauzeitung*, vol. 61, no. 2, p. 15, January 11, 1913. *d*). Description of the Vigeland hydroelectric plant and the 2000-h.p. Francis turbines used. The Bell-Criens governor is used and fully illustrated (Cp. *The Journal*, May, 1912, p. 792).

PHOTOGRAPHIC INVESTIGATION OF A PELTON WHEEL (*Photographische Untersuchung an einem Peltonrade*, R. Katzmayr. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 1, p. 7, January 10, 1913. 3½ pp., 7 figs. *deA*). Description of the apparatus used by the author for photographically investigating the flow of water in a Pelton wheel. The system of photographing is interesting, although not entirely satisfactory. It was found that the water jet as it comes from the nozzle is prismatic; it is divided, without being atomized, in two by the division plate of the double blade, and flows in a compact mass through the Cazin opening on to the second set of blades.

ON THE FLOW OF HEAVY LIQUIDS (*Sur l'écoulement des fluides pesants*, H. Villat. *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 1, p. 58, 3 pp. *m*). The author derives what may be called a general integral of permanent irrotational motion of a heavy liquid in two dimensions. His formulae apply to the flow of a liquid from an overflow, or a jet flowing through an opening in a solid wall, or a similar jet meeting an obstacle which may or may not divide it in two, and in general to all problems where the region occupied by the moving fluid may be represented, e.g. on a circle, in such a manner that the images of the solid walls in their entirety on one hand, and the images of all the free lines on the other hand, divide the limiting circumference in two distinct arcs. A rather complicated mathematical equation is derived which, judging by its appearance, cannot always be integrated in finite terms; when, however, the hydrodynamic problem itself, to be solved by the author's equation, is characterized by a geometric periodicity, the solution may be simplified by the application of the Fredholm equation of the first class, non-singular, and an integration in finite terms can be obtained.

Internal Combustion Engines

HEAVY OIL "KROMHOUT" ENGINE WITH IGNITION CHAMBER (*Moteur à huile lourde "Kromhout" à chambre de combustion incandescente*, O. H. Wildt. *Le Génie Civil*, vol. 62, no. 14, p. 261, February 1, 1913. 4 pp., 11 figs. *d*). For short runs on internal rivers and channels in Holland there is a demand for an engine that should be simpler and cheaper than the

Diesel engine. It should also be of very rugged construction, not require an engineer to run it, and use heavy oil, gasolene being too expensive for the purpose. The firm D. Goedkoop, Jr., of the Kromhout works, Amsterdam, Holland, have designed for this particular purpose the engine which they called "Kromhout" (Fig. 3 A). It works on the two-stroke cycle. In its upward stroke the piston takes in air through the leather flap valve *A*, and compresses it on the downward stroke in the air-tight carter *B* to the

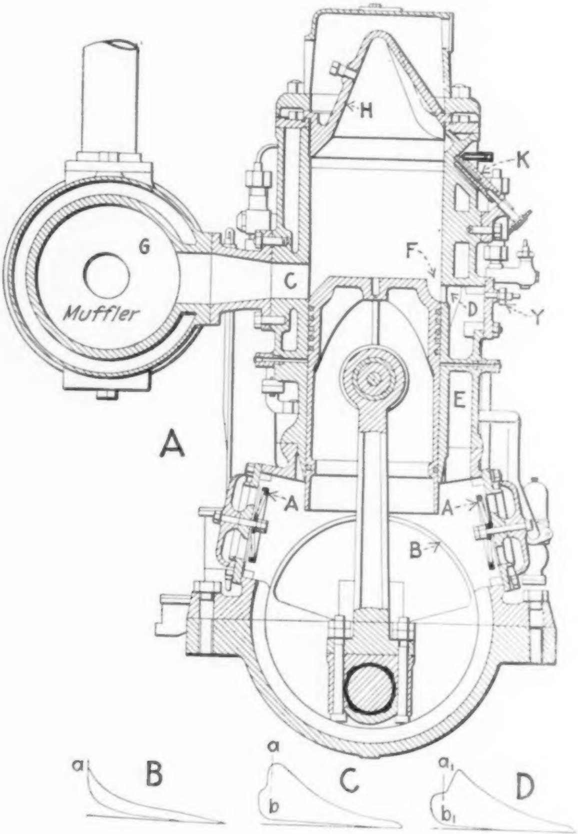


Fig. 3 Kromhout Heavy Oil Engine

moderate compression of 250 to 300 gr. per qcm (3.6 to 4.3 lb. per sq. in.). When the piston reaches the end of its downward stroke, it opens first the ports *C*, lowering the pressure of the gases of combustion down to atmospheric, and then immediately after the ports *D* which admit through the ducts *E* the compressed air from the carter into the cylinder. The notch *F* in the piston is of such a shape as to direct this stream of air upwards, and the air drives out the rest of the products of combustion.

The use of pure air (not mixture) for scavenging eliminates the possibility of loss of fuel in this connection. The compression chamber has the cast steel cone *H* which is heated to red heat by a special burner before the engine is started. The injection of the fuel through *K* begins at the end of the compression stroke, when the crank is about 30 deg. in advance of the dead point, and continues to the end of the stroke. Due to the action of the red-hot walls of the cone *H* and growing compression, the fuel is first vaporized, and then, at the dead center, the explosion takes place, the working stroke being the downward one. A hit-or-miss governor is used. Except in the smallest sizes, compressed gas is used for starting. The engine has neither poppet valves, nor slide valves, and no separate ignition. It can run in either direction, as started. It may be reversed by stopping the supply of fuel for some time and then renewing it when the piston is sufficiently in advance (practically what is known as reversing on the advance ignition). Since, however, this requires time, skill, and is somewhat uncertain in operation, the designers use a reverse gear.

The characteristic element of the Kromhout engine is its ignition chamber. The heat developed by the explosions is sufficient to maintain the cast steel cone red hot. There is even danger that at full load the cone will become so hot as to cause pre-ignition. To avoid this, water is injected from *Y* into the duct *E* which connects the carter and the cylinder. This water is taken from the cylinder jacket when the vessel is in sweet water, or from a special tank when at sea. The water reaches the cylinder in the form of a fine spray, and cools down the mixture as well as the cylinder walls and ignition cone. The amount of water injected is regulated by a special graduated valve. To determine the influence of the temperature of the ignition cone on the working of the engine, a series of tests were made at the laboratories of the builders of the engine, from which the three diagrams in Fig. 3 are reproduced: *B* is the normal diagram of the engine (it shows but little as to the phenomena of explosion, as they all occur too close to the dead point, where the piston is nearly stationary: region *a* of the diagram): *C* is the diagram taken with the ignition chamber too hot: the explosion takes place before the piston reached the dead point (*a-b*), and the engine is slowed down. The opposite happens with *D*, the diagram with the ignition chamber too cold, nearly black: here the ignition is considerably retarded. The best ignition was produced when the ignition cone had a temperature of 500 to 600 deg. cent. (932 to 1112 deg. fahr.).

THE LATEST TYPES OF GAS PRODUCERS (*Die letzten Erscheinungen auf dem Gebiete der Gasgeneratoren*, Gwosdz. *Feuerungstechnik*, vol. 1, no. 9, p. 164, February 1, 1913. 4 pp., 8 figs. *d*). Quarterly account of the improvements in gas producer construction. The improvements noted are mainly in secondary details.

KERPELY REVOLVING GRATE GAS PRODUCERS (*Drehrostgeneratoren nach System Kerpely*, A. Gobiet. *Journal für Gasbeleuchtung*, vol. 55, no. 22, p. 1273, December 28, 1912. 6 pp., 7 figs. *de*). Description and some data of tests of the three standard German types of the Kerpely gas producer.

THE PROBLEM OF THE GAS TURBINE (*Le problème de la turbine à gas*, E. Grauce. *Revue de mécanique*, vol. 31, no. 6, p. 509, December 31,

1912. 15 pp., 9 figs. *t*). General discussion of the various gas turbine cycles and their relative efficiencies. The treatment is purely theoretical, no new experimental data being reported.

NOVELTIES IN THE FIELD OF DIESEL ENGINE CONSTRUCTION (*Neuerungen auf dem Gebiete des Diesel-Motorenbaus*, H. Al. Siebeck. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 3, p. 25, January 17, 1913. 3 pp., 11 figs. *d*). Description of the latest types of the Diesel engines, in particular those built by the Pauksch Co., Landsberg a.W., Germany, and their fuel pump and atomization devices.

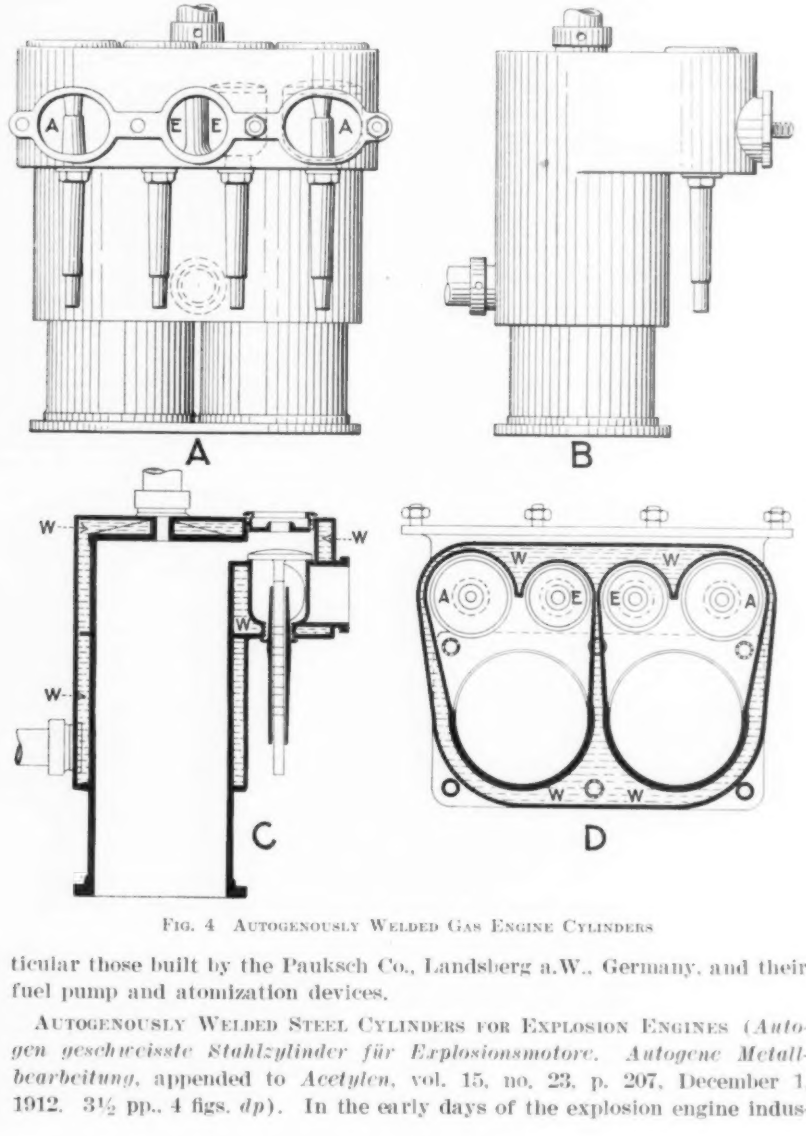


FIG. 4 AUTOGENOUSLY WELDED GAS ENGINE CYLINDERS

AUTOGENOUSLY WELDED STEEL CYLINDERS FOR EXPLOSION ENGINES (*Autogen geschweisste Stahlzylinder für Explosionsmotore. Autogene Metallbearbeitung*, appended to *Acetylen*, vol. 15, no. 23, p. 207, December 1, 1912. 3½ pp., 4 figs. *dp*). In the early days of the explosion engine indus-

try an attempt was made to make the *cooling jacket of sheet metal*, and to solder it to the cylinder, but the soldering metal was different from that of the pieces united by it, and with the aid of the acid always present in the cylinders, an electric couple used to be created which led to the rapid destruction of the soldered joint. *Oxyacetylene welding* was found to give a much better method of *cylinder construction* in which only seamless piping and pressed mild steel sheet parts are used. Fig. 4 shows two and one cylinder sets of the Stahlmotoren-Gesellschaft Ernst Jaenisch & Co., of Berlin, Germany, which are said to have been tested on the stand and on an automobile for 1½ years and to have given fully satisfactory results. The advantages of these types of construction are supposed to be: the welded construction is easier to manufacture and more reliable in execution that an iron casting; the expansibility of mild steel is very much superior to that of cast iron, and the material more uniform, so that should even the water cooling fail for a time, there would be considerably less tendency for cracks to be formed: as shown in Fig. 4 C and D both the explosion and the valve chambers are entirely surrounded by cooling jackets which produces a better cooling than is possible in the case of a cast cylinder; the walls of the entire construction are of uniform thickness, and a thickness of 1.5 to 3 mm (0.06 to 0.118 in.) is sufficient for the mild steel plate of the cooling jacket; by this *a saving of about two-thirds in the weight of the cylinder is obtained*, a fact of material importance even for automobile construction, but tremendously more so for aeronautical engines (the article quotes a case of a reduction of the weight of the cylinder plant from 48 kg (106 lb.) for cast iron to 15 or 18 kg (33 or 39.7 lb.) for autogenously welded steel construction. Cast-iron construction involves a large outlay for patterns, with corresponding increases whenever new sizes are adopted, while with welded construction there is no need for patterns, and any sizes may be made by the same methods and appliances: experience has shown that thoroughly reliable work can be turned out under shop conditions, with all possibility of overheating the cylinder jackets being entirely eliminated. Each cylinder is submitted to a cold water pressure test at 100 atmospheres, and it is said that untight places are of rare occurrence even at this comparatively high pressure. It is further stated that while an appreciable percentage of cylinder castings is usually spoiled and goes to scrap, this is entirely eliminated with the new method of cylinder construction. The tests have shown that welded cylinders are also more efficient because the valve cross-section may be made comparatively larger owing to the walls being thinner, and because the mathematically correct distribution of passages and explosion chambers with respect to the piston permit a much higher compression.

New Gas Producer (*Novjy Gasogenerator, Dvigatel*, vol. 6, no. 24, p. 498, 1912. 1 p., 2 figs. *d*). Description of a *new gas producer* designed by a Russian engineer A. Simonenko. It is very much like the Rincker and Wolter producer described in *The Journal*, November 1912, p. 1881, with the difference, however, that it is intended to be used with peat as fuel, and the air and gases from the first shaft move in the second shaft upwards and not downwards as in the Dutch type. From the description of the

Simonenko gas producer it appears that there is no provision for alternating the direction of the flow of the gases between the shafts, as in the Rincker and Wolter, and the Berlin-Anhalt Company's types.

H. PIERPER GASOLINE-ELECTRIC CARS (*Automotrices pétroléo-electriques, système H. Pieper*, M. Hegelbacher. *Le Génie Civil*, vol. 62, no. 11, p. 201. 3 pp., 5 figs. *d*). Description of the Pieper *gasolene-electric car* used now on many suburban lines in Belgium and France. The motive plant consists of: (*a*) an explosion engine of average capacity corresponding to the average power required on the given line; (*b*) a direct-connected dynamo serving also as flywheel of the engine; it is shunt wound, and may act either as a generator or as a motor, at speeds varied by the field excitation; (*c*) a storage battery of 60 cells, divided into four sets, placed in pairs under the front and rear platforms of the car. When the car comes to a grade which the engine would be unable to handle, it is helped out by the storage battery; the battery is recharged by the dynamo acting as a generator on the downgrade sections of the run, the voltage adjustment between the two being regulated automatically. An interesting feature of this car is the *regulation of the admission of gas* to the engine *governed by a solenoid* with two windings inside of which moves a soft iron core acting on the gas admission organs. This regulator decreases or increases the gas admission according as the current passes into the battery or from it, so that on an upgrade the engine works at full admission, while on the downgrade the regulator closes automatically and admits just enough gas to allow the engine to overcome its passive resistances, the energy of the gravity driving the dynamo as a generator and charging the storage battery. Storage batteries are, however, expected to help the motor out only on comparatively moderate grades; when the run of the car includes steep and especially long upward grades, the engines must be made proportionally stronger, the principle of the system demanding that the *engine* furnish the *average* power required for the given run.

Mechanics

ON THE CALCULATION OF BELT TRANSMISSIONS (*Note sur le calcul des transmissions par courroies, Bulletin trimestriel de l'Association des Ingénieurs de l'Ecole Supérieure de Textiles*, no. 1, March 31, 1912 (?), p. 35, through *Le Mois scientifique et industriel*, vol. 14, p. 576, December, 1912. *p*). The most favorable speed is 20 to 25 m (65 to 82 ft.) per sec. for oak tanned belts, and 30 m (98 ft.) per sec. for chromium treated leather belts; the most convenient working tension 400 to 600 gr. per qmm (568 to 852 lb. per sq. in.). The section of the belt is given by the formula:

$$s = F\frac{efa}{efa-1} \times \frac{1}{R - \frac{\delta v^2}{g}}$$

where F is the power transmitted; e the Naperian base; f coefficient of adherence; a arc of contact with the small pulley; R tension per unit, permitted; δ weight per unit of volume; v velocity per sec.; g acceleration for the unit adopted. The thickness of the belt should be from 1/20

to 1/30 of the radius of the pulley; for chromium treated pulleys, which are more elastic, 1/15 or even 1/12 may be permitted; a chromium treated leather belt, 10 mm (0.39 in.) thick has given good results on a pulley 120 mm (4.7 in.) radius. As to the axial distance, when the pulleys are of unequal diameter, it has to be selected so that $\frac{D-a}{2\delta} \geq 0.25$, where D is the diameter of the pulley; for pulleys of equal diameter, $\delta = 3D$ minimum. The life of a belt is inversely proportional to the coefficient of fatigue. This coefficient $f = K\frac{e+R}{R} \times \frac{V,}{\delta}$, where K is from 1 to 3, depending on the kind of machine and surrounding condition. (The article does not state the kind of units used in the equation: the usual continental units are probably used. The same notation for the coefficient of fatigue of the belt material and coefficient of adherence is used).

On the Realization of High Angular Speeds (*Étude sur la réalisation des grandes vitesses angulaires*, Maurice Leblanc. *La Lumière électrique*, vol. 20, nos. 51 and 52, pp. 355 and 387, December 21 and 28, 1912. And vol. 21, nos. 1 and 2, pp. 7 and 35, January 4 and 11, 1913. 27 pp., 32 figs. *mtA*). There are many cases in which it would be desirable to run wheels at great peripheral speeds, e.g. in large single-stage steam turbines which could be built in any size if their blades could be economically given the required speed. This cannot be done, however, by making the angular speed moderate and giving the wheel a large diameter, because the work absorbed by friction against the surrounding medium grows as the fifth power of the diameter, and only as the cube of the angular speed; in addition, a large wheel running at a peripheral speed of over 1,000 ft. per sec. is a dangerous piece of apparatus, and would have to be enclosed in a cage of which the weight grows rapidly with the diameter of the wheel. It is therefore of advantage, in order to obtain a large peripheral speed, to increase the angular speed rather than the diameter of the wheel. As to what a large single-stage turbine running at a high angular speed could drive, the author states that there are already such compressors, and that he has designed an alternator which would furnish current at commercial frequencies (15 to 50 cycles) when driven at considerably higher speeds.

The difficulty with machinery of usual construction running at high angular speeds is that the rotors and foundations must be of large mass and great rigidity in order to prevent the rise of vibrations; and even with that at starting and stopping, when the frequency of oscillations is apt to vary continuously, there is a great risk of falling into resonant oscillations which produce unforeseen fatigues both in the stator and rotor. Small machines running at high angular speeds and having rigid shafts and fixed brasses are heavier, in proportion to the power developed than larger machines rotating more slowly; also the friction at the bearings absorbs more power, and the efficiency is therefore lower. There are also other disadvantages, such as the nearly absolute impossibility to balance the rotor when it is partly formed of organic substances deformable in their

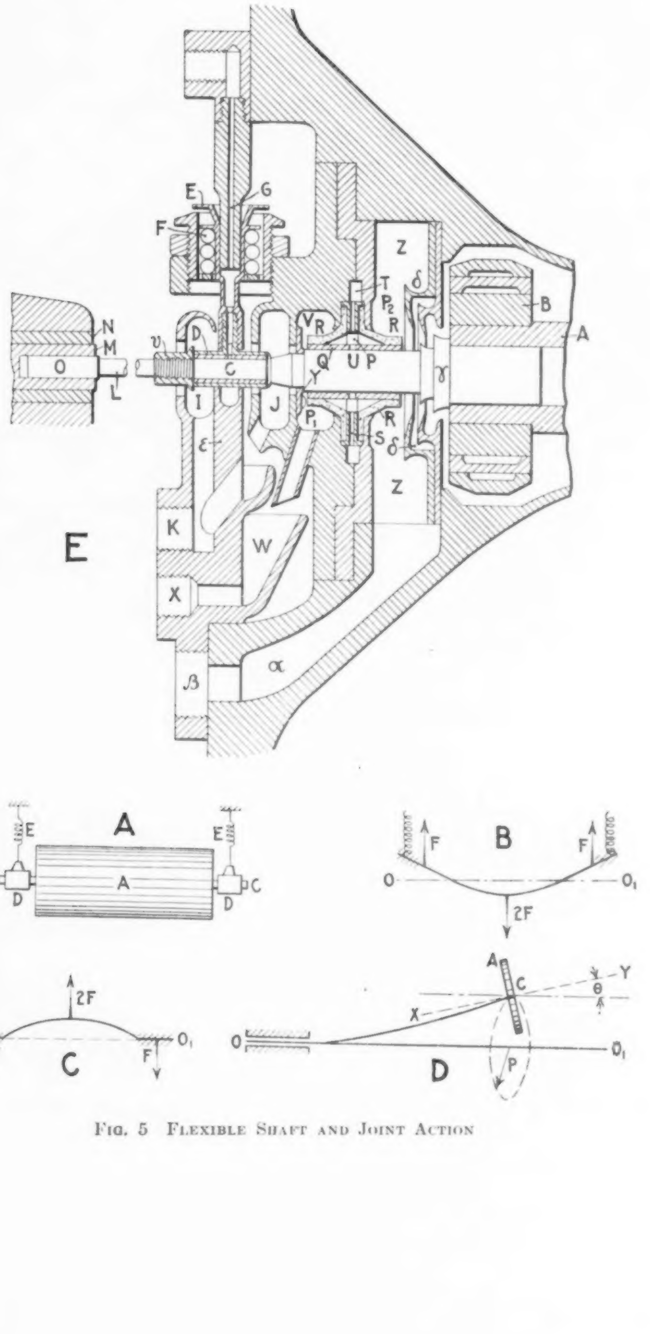


FIG. 5 FLEXIBLE SHAFT AND JOINT ACTION

nature. *Most of these disadvantages disappear when the rotor is enabled to select at each instant its own axis of rotation just as a spinning top does on a perfectly smooth surface.* The problem is therefore, to support the rotor by elastic elements, while transmitting to it a couple if necessary, in such a manner that its real axis of rotation coincide as closely as possible with the axis of the figure of the stator; that would to a certain extent limit its freedom of motion, but forces acting in this way are very small in comparison with those which make it turn about its axis of the figure, and would not affect its output, while at the same time the bearings of the shaft could be made smaller and thus absorb less power in friction; the smaller the external forces limiting the freedom of motion of the axis, the less will be the amplitude of vibrations communicated to the stator, and such vibrations can be made entirely harmless (unless resonant oscillations arise, which ought to be carefully avoided). It is, however, clear that it is practically impossible to make a well balanced rotor rotating around the *axis of its figure* if it has a rigid shaft and fixed brasses, although this may be done when the rotor rotates about its *axis of inertia*, i.e., axis passing through or extremely near to the center of gravity of the rotor. To obtain smooth running at high angular speeds it is necessary to fulfil simultaneously *two* conditions: freedom of motion of the rotor and good balancing; fulfilling only one is not sufficient. With small rotors, i.e. exactly those where it is necessary, it is extremely difficult to obtain good balancing, but the author states that he has solved this problem by adapting automatic balancing devices to rotors free to select their own axis of rotation.

To do this in practice is comparatively simple when the driven apparatus is direct-connected because in that case there is only a single rotor and the shaft has to be supported only, but does not transmit any couple. If, however, no direct connection is used, then a couple is transmitted between a shaft with a fixed axis of rotation to that of a rotor which is free to select its own axis. Such a shaft has of course to be flexible. The author uses the term *flexible shaft* when it transmits a couple and supports the rotor at the same time, but calls it a *flexible joint* when the rotor is supported as shown in Fig. 5 A. In this latter case the rotor is provided with journals *C* lying on very light brasses *D* and in their turn supported on the two springs *E*: by varying their tension or bending, the rotor can move either horizontally or vertically. The journals must be as small and short as possible, and their dimensions are selected as if they had only the rotor to support; this allows the use of lighter bearings. Since there are springs, there is a fear of resonances arising at a critical speed, but, if the suspension springs are made very flexible, the critical speed may be made to be very low, and then there is no danger in clamping the bearings at starting until the critical speed is passed, and doing the same in stopping the engine. This is a simple way to eliminate resonant oscillations, and may be made entirely automatic.

The next danger is the deformation of the rotor. To prevent this it is necessary that the critical speed of the rotor itself, which corresponds to the mode of suspension and is different from the critical speed discussed in the preceding paragraph, be considerably above the maximum

speed which it will have. A rotor in passing through its own critical speed becomes subject to dangerous deformations: its journals begin to jump causing fatigue to the bearings and springs, and it is liable to be ruptured. If the engine is a turbine driving a dynamo without a rheostat, the danger due to the critical speed may be avoided by giving the rotor a very large positive or negative acceleration in that neighborhood; this may be done by not exciting the field at starting, and leaving it excited in stopping. But when there is a rheostat there is considerable danger, and it is a good plan to limit the normal speed to about two-thirds of the first critical speed of the rotor proper. Since the rotor does not rest on fixed bearings, it cannot form an arch as shown in Fig. 5 C: the only way it can arch is by finding a fulcrum on itself, as shown in Fig. 5 B, but to produce that kind of deformation, a velocity considerably higher than that producing the deformation of Fig. 5 C is necessary, and in practice a rotor can nearly always be designed to keep well below that limit. Since further in geometrically similar rotors made of the same materials, the critical velocities of the rotors proper are inversely proportional to their linear dimensions, it follows that as the linear dimensions of the rotors decrease, higher angular velocities may be communicated to them with the same degree of safety, just as required in this case. *The absolute magnitude of the angular velocity has no importance whatever so long as it is below the critical velocity of the rotor proper.*

Theory of the Flexible Shaft. Let OO' be the axis of the brasses O (Fig. 5 D) and also the axis of rotation. The flexible shaft carries a rotor A having its center of the figure C located on its neutral axis. The axis of the figure xy of the rotor is tangent to its neutral axis at C. The angle θ is by supposition so small that $\sin\theta = \theta$ and $\cos\theta = 1$.

The author shows that if under these conditions a rotation is communicated to the deformed flexible shaft at a speed ω about a fixed axis OO', and if it is further given a speed of precession α, about that axis, the rotor on the shaft will rotate at a speed $\omega - \alpha$ with respect to the neutral axis of the shaft. A flexible shaft permits therefore of transforming a movement of pure rotation about the axis OO' at speed ω into a movement of rotation of speed $\omega - \alpha$ about an axis xy, and a movement of precession of speed α referred to the axis xy. This reduces both the bending effort on the shaft acting when its axis does not coincide with the axis OO' and the stresses on the brasses which support it, since these stresses depend now not on the speed ω, but on α. This also produces some gyroscopic phenomena which in their turn tend to increase the stability of operation.

Flexible Joint. The author investigates in detail the conditions regulating the selection of a flexible shaft or flexible joint, the latter having the advantage of not being deformed by the weight of the rotor or by clamping the brasses at a time when the system passes through its critical velocity. Fig. 5 E shows the design of the flexible joint which the author adopted after considerable experimentation. The rotor A provided with automatic balancers (one of them can be seen at B) ends in two journals, short and of small diameter, one of which is shown at C. Each of the journals rests on a brass D as light as possible and supported by a sus-

pension piece *E* which is in aluminum and rests on rubber washers *F*. Lubricating oil is brought to *E* by the pipe *G*, and passes further to the center of the brass by the hole *H*. On the surface of the brass two helicoidal grooves are cut, one to the right and the other to the left, starting from *H* to the interior. The oil is carried away by the rotation of the journal, and provides for its lubrication no matter what position may be taken by the journal.

In the last section of his article the author discusses a system of automatic balancing by means of two hollow tores filled with mercury. In view of the interest and comparative novelty of this device, a more complete description will be given in an early issue of *The Journal*.

Pumps (See Also Air Machinery)

ACTION AND DESIGN OF AIR VESSELS IN PLUNGER PUMPS (*Wirkungsweise und Berechnung der Windkessel von Kolbenpumpen*, Gramberg, *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 129, 1912. 62 pp., 34 figs. *etA*). The author has found experimentally that resonance phenomena may take place in the piping of plunger pumps when the natural frequency of the water column acted on by the pressure of the air vessel is in a suitable ratio (expressed by integral numbers) to the speed of rotation of the engine. These resonance phenomena produce large extra pressures and may therefore be quite dangerous; in addition they consume extra power, in some cases as much as 35 per cent. The usual statico-volumetric theory of the air vessel is therefore declared to be unsatisfactory. The author insists that the dimensions of the air vessel be a function of the speed of rotation, delivery pressure, and size of pressure piping, but independent of the lift space; he derives several equations in accordance with these principles. When several pumps work with several air vessels, all cases of possible resonance must be foreseen, and provided against by giving the air vessels proper dimensions.

DROUVILLE MULTICYLINDER FIRE AUTOMOBILE PUMPS (*Pompe à incendie multicylindrique système Drouville*, D. Duaner. *Le Génie Civil*, vol. 62, no. 14, p. 271, February 1, 1913, 2 pp., 5 figs. *d*). Description of the Greindl two-axis rotary pump and Drouville multicylinder pump. The Greindl pump has an arrangement somewhat similar to that of the Root blower, while the Drouville pump has four crosswise disposed single-acting cylinders, the four pistons acting successively in the order of rotation, and thus producing a constant flow of water in the same direction. This arrangement permits of reducing the clearance spaces, while a supplementary arrangement of the pump body in the form of two annular and concentric chambers eliminates the possibility of eddies and water hammering.

THE NEUMANN INVOLUTE PUMP AND ITS PROPERTIES (*Die Evolventenpumpe "System Neumann" und ihre Eigenschaften. Der praktischer Maschinen-Konstrukteur*, vol. 46, no. 2, section "Pumps," p. 2, January 16, 1913. 2 pp. 11 figs. *d*). In *The Journal*, August, 1912, p. 1254, reference was made to a new principle of pump construction. The following is an abstract of what is claimed to be the first published statement of what this principle is. It is claimed that in this pump the water

is conducted in the passages between blades in such a way that the velocity-pressure conversion is nearly perfect. The vertical section of the blade wheel profile is said to be usually limited by two bodies of revolution; equal blade heights are therefore on concentric circles, and the individual sections *a-a*, *b-b*, etc. (Fig. 6, A) are therefore trapezoidal, which in itself indicates a poor design of the passage between the blades. This was further proved by tests (not stated where made) of a centrifugal pump wheel similar to that of the pump used for driving the illuminated fountains at the Nuremberg Exhibition in 1906. In that pump there were two wheels each of which had to deliver 6.5 cbm (230 cu. ft.) per min. at a height of 50 m (164 ft.). By calculation the entrance velocity in the runner passages at *a* was found to be 16 m (54 ft.), the outlet velocity at *c* 7.8 m (25.6 ft.) The velocity fall from 16 m to 7.8 m had to produce a pressure head of $(16^2 - 7.8^2) : 2g$, or about 10 m (32.8 ft.). As shown by the dotted curve in Fig. 6, B, where the ordinates are the average velocities at different cross-sections, and the abscissae the respective cross-sections, there is a very rapid velocity fall from *a* to *c*; from *c* on the deceleration is much slower, and in *d* the velocity reaches its minimum of about 6.8 m (22.3 ft.), the velocity rising to about 7.8 m (25.6 ft.) at the outlet.

Such a shape of the characteristic curve, with its uneven deceleration and acceleration, is of course not favorable to the production of the most efficient velocity-pressure conversion, which results in shocks, in their turn reducing the regular action and efficiency of the pump. All these defects are said to be eliminated in the new wheel shown in Fig. 6, C. All the runner passages have exactly rectangular cross-sections so proportioned that the velocity curve is a straight line (the full line in Fig. 6, B), the most conducive to perfect velocity-pressure conversion. Fig. 6, D shows the profile of such a runner. The upper limiting line is still part of a body of revolution, but the lower is not; further, equal passage heights are to be found not along concentric circles, as hitherto, but in equal cross-sections normal to the direction of the flow of water, the blade passage produced being as shown schematically in projection in Fig. 6, E: all the cross-sections are rectangles, with areas steadily increasing up to the outlet, the passage between the blades having really the form of a conical tube with rectangular cross-section.

Improvements in the rim clearance arrangement is also claimed. The usual arrangement is such that the water flowing with great velocity from the rim strikes normally the water flowing through the suction pipe which produces strong eddies, noise and loss of efficiency. In the arrangement shown in Fig. 6, F the water coming out from the rim is deflected so as to flow in the same direction as the water flowing in the suction pipe which not only eliminates the eddies, but helps to recover part of the energy stored up in the water coming from the rim: this water acts in the suction pipe somewhat as an ejector, and permits the use of a shorter suction pipe. Fig. 6, G, taken from *der praktische Maschinen-Konstruktieur*, vol. 45, no. 12, shows a 12-stage, high-pressure involute pump built by the Armaturen- und Maschinenfabrik- A-G. vorm J. A. Hilpert in Nuremberg, or rather one-half of it having 6 of the 12 stages, this part of the pump designed to deliver 3.3 cbm (116 cu. ft.) per min. 260 m (852 ft.) high. Its efficiency is said to be 78 per cent.

High-Pressure Centrifugal Pumps used for Fire Engine Work (*Pompes centrifuges à haute pression employées comme pompes à incendie, Bulletin technique de la Suisse Romande*, vol. 39, no. 1, p.1. January 10,

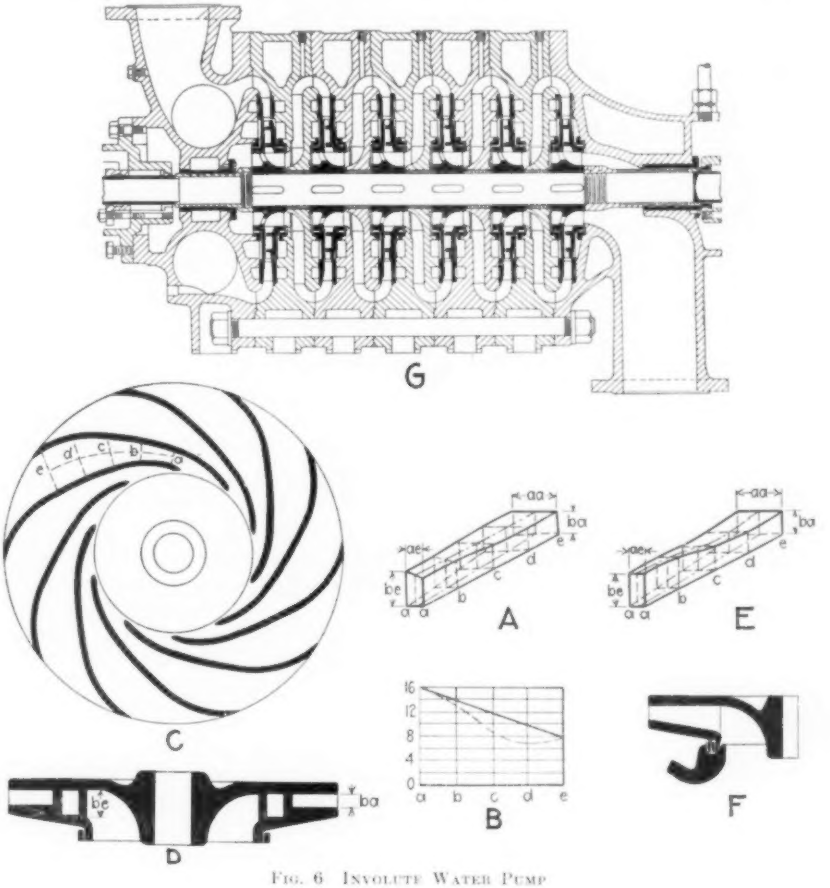


Fig. 6 Involute Water Pump

1913. 7 pp., 12 figs. *de*). Description and data of tests of the Sulzer type centrifugal fire engine pumps and Sulzer motor driven fire engine.

Steam Engineering

Regulation of Hot Steam Temperatures (*Die Regelung der Heissdampf temperaturen*, Generlich. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 48, p. 1946. 2½ pp., 3 figs. *de*). *The temperature of superheated steam* is a function of many factors not easily controlled, and all attempts to regulate it by flaps, mixing valves, etc., are connected with certain difficulties of operation. The German Babcock & Wilcox Co. has patented a new type of superheater in which first the entire steam generated by the boiler is superheated, and then, by means of a patent three-way mixing

valve, the steam is taken either direct from the superheater, or first led through a ribbed pipe lying in the water space of the boiler, where it gives up part of its heat to the cooling water. This steam of lower temperature may then be added to the superheated steam coming direct from the superheater. The temperature may be varied within a range of 80 to 175 deg. cent. (144 to 315 deg. fahr.). The advantages of the new superheater type are said to be: full utilization of the superheater surface, absence of superheater flaps, and better regulation of temperature than is possible with an ordinary mixing valve.

SIMULTANEOUS PRODUCTION OF ELECTRIC ENERGY AND HEAT (*Production simultanée d'énergie électrique et de chaleur*, A. Beaurienne. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 65, no. 11, p. 701, November, 1912. 40 pp., 24 pp. *dg*). A compendium on the utilization of heat as a by-product of steam motive plants.

UTILIZATION OF LOW-COST FUELS AT THE MINES OF THE DORTMUND MINING DISTRICT (*Ausnutzung minderwertiger Brennstoffe auf Zechen des Oberbergamtsbezirks Dortmund*, Bütow and Dobblestein. *Glükauf*, vol. 48, no. 52, p. 2101, December 28, 1912. 3 pp, 3 figs. *e*). Data of tests with *coke breeze as fuel* at the new plant of the Minister Achenbach mine in Brambauer, Germany. The plant consists of four double-blue boilers, 96.4 qm (say 1070 sq. ft.) heating surface each. The boiler under test was fitted out with a Wilton closed ashpit furnace, with a grate area 2.47 qm (26.5 sq. ft.), and a consequent ratio of grate area to heating surface as 1:39; the boiler was previously in operation for several weeks. The steam blower consumed the first day 74.3, and the second 86.5 kg (166 and 192 lb.) of steam per hour. With a chimney draft of 5.3 mm (0.21 in.) of water, an average of 15 kg of steam per qm (3.08 lb. per sq. ft.) of heating surface was generated, and the tests have demonstrated on the whole that even with a poor draft, a closed ashpit furnace permits of burning coke breeze economically. With the cost of fuel taken at M2.18 per ton (say $0.48 per short ton), and the price of a Wilton furnace for a double-flue boiler at M1000 (say $385.00), the cost of steam was about M0.85 per ton (say $0.185 per short ton). The iron chimney, 22.8 m (say 75 ft.) high was later replaced by another, 60 m (196 ft.) high, and tests were made to determine the comparative losses of a Wilton and a horizontal grate furnace; it was found that with the first an economy of about 15 per cent was obtained. The article contains full data of the tests.

DEVELOPMENTS IN THE GERMAN SECTIONAL BOILER INDUSTRY (*Neue Wege der deutschen Gliederkesselindustrie*, Pradel. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 1, p. 1, January 3, 1913, 8 pp., 33 figs. *dh*). Description of various new German types of cast-iron *sectional boilers* for heating purposes, with a short historical sketch of the development of the various types. Interesting as a compendium of the German heating boiler practice; no new types are described.

THE IMPORTANCE OF HOLLOW WATER COOLED GRATES FOR THE INDUSTRY GENERALLY AND FOR NAVIGATION (*Die Bedeutung des wassergekühlten Hohlrostes für die gesamte Industrie und Schiffahrt*, H. Dinkgreve. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 1, p. 4, January 3, 1913.

4 pp., 4 figs. *dg*). From a paper read before the Hannover Section of the Verein deutscher Ingenieure, November 29, 1912. A brief description of the types of *hollow water cooled grates* and detailed discussion of their advantages. In the Grabowsky construction a double header is used and the grate bars are welded in, the bars, however, having freedom enough to expand with heat. The water used for grate-bar cooling is returned to the feedwater tank in land boilers; in marine boiler practice sea water is used for cooling, and returned overhead. The article quotes the following test data:

No. of test	1	2	3
Water evaporated, kg/lb	30200/66440	33305/73271	4206/9253
Cooling water, kg/lb	25756/56663	23855/52481	5319/11702
Actual gain in temperature, cent./fahr	33.4/60.3	37.7/67.5	19.1/34.4
Gain in temperature, reduced to feedwater, deg. cent./fahr	28.6/51.3	27.0/48.6	24.0/43.2

In this table tests 1 and 2 were made by the Hamburg Association for Smoke Prevention, and 3 by the Hannover Association for the Inspection of Steam Boilers. As regards the amount of coal burned per unit area, which in the case of marine boilers may be quite large, the sections of the bars and their inside cooling is proportioned so that the bars, even

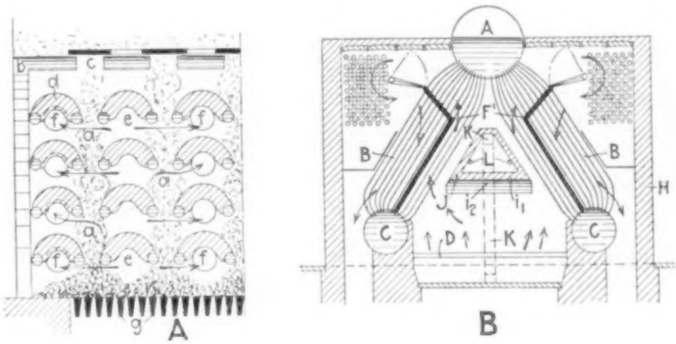


FIG. 7 PAMART AND KRUPP FURNACES

when 2.5 m (8.20 ft.) long may have sufficient cooling to admit loads from 300 kg. per qm-hr. (61 lb. per sq. ft. per hr.) of grate area, without affecting in the least the life of the grate bars. A further advantage of the hollow grate bars is the smaller amount of cleaning and clinkering. During the above quoted tests at Hanover it was found that while the solid cast-iron grate had to be cleaned five times during the 7.12 hr. of the test with an expenditure of 10 to 15 minutes each time; during the 6.13 hr. of the tests of the hollow water-cooled grate bars, only one cleaning near the end of the test was required which took less than 5 minutes. The water-cooled grate bar is also more efficient thermally, since it takes up nearly all the radiation directed downwards and permits the heat to be taken up by the cooling water; in the case of solid grate bars only part of this heat is utilized for preheating the air. The average saving in fuel due to all causes was found to be on the average about 5 per cent.

It is further stated that the absence of clinker on the grate due partly to the absence of frequent cleaning of the fire and consequent cooling of the fuel bed helps to produce a practically smokeless combustion. As far as the efficiency of the boiler is concerned, however, perhaps of most importance is the simplicity of taking care of the firing with hollow water-cooled grate bars permitted by the use of very long grates, up to 2.5 m (8.20 ft.) which, together with other things, is said to raise the efficiency of the boiler installation from 30 to 50 per cent. The German Navy ordered installed for testing purposes, a hollow water-cooled grate on its latest cruiser "Blücher."

NOVEL FEATURES IN SOLID FUEL FURNACE PLANTS (*Neuerungen bei Feuerungsanlagen für feste Brennstoffe*, Pradel. *Feuerungstechnik*, vol. 1, no. 8, p. 147, January 15, 1913. 3 pp., 10 figs. *d*). Quarterly account of the novelties in *furnace types*. In the furnace of E. L. Pamart, of Paris, France (Fig. 7 A), the furnace walls *b* are filled with water. The fuel (very small coal or even coal powder), is charged through the openings *c* provided with regulating slide valves. The furnace proper is divided grid-work-wise by the little bridges *d* supported on water filled pipes connected with the water jacket of the furnace. The bridges are staggered, and the fuel, before falling upon the grate, piles up on them for a short time. The spaces are limited by two small bridges *d* from above and below and by the piles of fuels on the sides, and are connected in alternate rows either with air admission openings *e* in the front wall, or with the air outlet openings *f* on the rear wall, so that the air travels in the direction of the arrows, and forces its way through the fuel piles.

Fig. B shows a water tube boiler built by the Germaniawerft of the Krupp Company. Its peculiarity consists in that an air preheating set *j* is built in above the grate between the tubes of the boiler. It is made of fire proof material, runs from the front wall to the rear; the lower wall *i*[1] is built like a supporting arch, while the side walls run parallel to the longitudinal direction of the tube nests. The preheated air is conducted below the grate by the pipe *k*. The preheating element is proportioned so that there is plenty of room for the gases to flow around it to the boiler tubes, and enough space below it for proper combustion.

Strength of Materials and Materials of Engineering

CONTRIBUTIONS FROM THE ROYAL TESTING LABORATORY AT GROSS-LICHTERFELDE WEST (*Mitteilungen aus dem Königlichen Materialprüfungsamt zu Gross-Lichterfelde West*, vol. 30, no. 4, 1912):

(*a*) INFLUENCE OF TIME-RATE OF INCREASE OF LOAD IN COMPRESSION TESTS OF CEMENT CUBES ON THE RESULTS OF THE TESTS (*Einfluss der Belastungsgeschwindigkeit bei Druckversuchen mit Zementwürfeln auf das Prüfungsergebniss*, H. Burcharz, p. 181. The tests have shown that the results of tests are influenced by the speed with which the load increases: the faster the load increases, the more favorable seem to be the results; the higher appears to be the rupturing load. An Amsler-Laffon press with a mercury column was used in these tests.

(*b*) ACCELERATED TESTS FOR CONSTANCY OF VOLUME OF PORTLAND CEMENTS (*Beschleunigte Prüfung der Raumbeständigkeit von Portlandzemen-*

ten, Professor M. Gary, p. 196). Full publication of the paper presented by the author at the Sixth Congress of the International Association for Testing Materials (XIV 2, no. 9).

(*c*) CONTRIBUTIONS TO THE TESTING OF BALLOON MATERIALS (*Beiträge zur Prüfung von Ballonstoffen*, K. Memmler, p. 202, 10 pp., 5 figs.). Description and data of tests of the *bursting strength of balloon materials*. The Gradenwitz apparatus for testing balloon materials had the disadvantage of using large pieces of material (570 mm., or 21 in. in diameter) which made the test expensive, and when such large pieces could not be obtained, impossible. The new apparatus designed by Professor Martens and fully described in the original article can test pieces of 0.01 to 0.3 qm (0.1 to 3.2 sq. ft.) area, and can handle elliptical, triangular, and other shapes just as well as circular pieces. The apparatus consists essentially of two flasks of compressed air supplied to the lower side of the cloth under test which is held by metal rings against a rubber basis. The arching of the cloth is recorded on a paper drum which rotates proportionally either to the time elapsed, or to the air pressure producing the arching: two manometers are used: one to show the air pressure applied to the cloth under test, the other that in the air flasks. The test gives two series of data: bursting pressure p and height of arching h. For the determination of the bursting strength of the cloth the formula given in Moedebeck's Pocketbook has been used, and it was found that the bursting strength of the material as determined by means of this formula decreases with the increase of the radius of the piece under test. It was also found that the tearing strength (Zerreissfestigkeit, stress in the direction of each thread) of the material under the test conditions amounted to only about 60 to 70 per cent of the bursting strength (Zerplatzfestigkeit). It was further found that the humidity in the air has a material bearing on the data of tests.

(*d*) TESTING OF PLASTIC MORTARS (*Prüfung plastischer Mörtel*, M. Gary, p. 214, 10 pp., 9 figs.). Preliminary publication of part of the data presented by the author at the Sixth Congress of the International Association for Testing Materials (XIII 2, no. 9).

DRILLING TEST FOR THE DETERMINATION OF THE HARDNESS AND MACHINING QUALITIES OF METALS (*Der Bohrversuch zur Bestimmung der Härte und Bearbeitungsfähigkeit von Metallen*, O. *Bechstein*. *Prometheus*, vol. 24, no. 1210, p. 217, January 4, 1913. 2 pp., 3 figs. *de*). As early as 1899 Mr. W. Keep pointed out that hardness and machinability of a metal may be determined by drilling, since in a given time, with a given power applied and speed of rotation used, the depths of drilled holes are proportional to the hardness or machinability of the respective materials. Alfred H. Schütte, of Cologne, Germany, have placed on the market an attachment (Fig. 8 A) which may be placed on any drilling machine, in which the rotation of the drilling spindle is transmitted to a small screw spindle; on the latter, in accordance with the rotation of the spindle, a nut moves upwards, guided by two lateral guide rods and carrying a pencil pressed by a little spring against a paper covered drum, the ratio of transmission being usually so selected that a vertical displacement of 1 mm (0.039 in.)

of the pencil point on the indicator drum corresponds to two revolutions of the drilling spindle. On the journal which usually carries a hand wheel for feeding the drilling spindle, is placed a balance lever consisting of two quadrants, a small one on the left, and a large one on the right, with a weight attached to drive the indicator drum at a uniform speed. During the test, the vertical motion of the pencil point along the paper of the drum due to the rotation of the drilling spindle is deflected by the feed of the spindle which is a function of the depth of the drilled hole, and the line made by the pencil on the drum is an inclined one, as shown in Fig. 8 B, where the speed of the drill is used as ordinates, and the drill hole depths as abscissae. When the material is homogeneous, the line is straight; otherwise it is curved. This device is of interest for it appears to be cheap enough to be used even in small machine shops, and it gives simultaneously and in a short time indications as to the properties of materials sufficient for most practical purposes.

HOW TO RECOGNIZE GOOD LUBRICATING OILS (*Wie erkennt man gute*

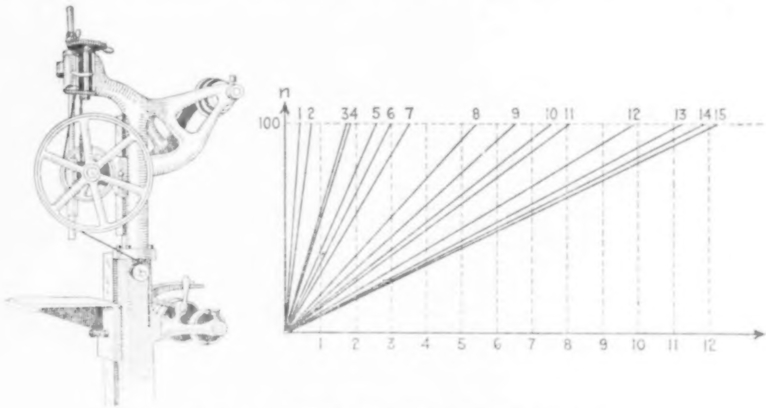


FIG. 8 HARDNESS DETERMINATION BY DRILLING

Schmieröle? F. Gelbig. *Braunkohle*, vol. 11, no. 41, p. 657, January 10, 1913, 2 pp. *p*). Practical directions for *determining roughly the qualities of lubricating oils* without the use of special testing apparatus. To detect the presence of solid impurities in the oil, to half a tumbler of oil kerosene is added until the whole becomes quite thin. The mixture is then filtered through filter paper or ordinary white blotting paper, and after all the oil has passed through, the paper is washed with kerosene; the residue on the paper, if any, will show if the oil had any solid impurities. Impurities may also be roughly detected by smearing a piece of writing paper with oil and holding it against light; if the oil is free from solid impurities, the blot will be equally transparent throughout; otherwise, the solid particles will show. The oil must not resinify: to test it in this respect, it is enough to pour it into a shallow dish and leave in a warm place about a week: there must not be the slightest crust at the end of that time. Another way to test it is by mixing it with

fuming nitric acid: if the oil is pure, a thick mass will form in a few hours, while resinifying oil will remain thin. Acids are very injurious impurities in lubricating oil acids since in time they attack the machine parts lubricated. To test for them, copper oxydul or copper ash is added to the oil in a glass vessel: acid-free oil retains its original color, while, if it contains acid, it becomes greenish or bluish. Another test is to drop the oil on a sheet of copper or brass and leave it so far a week; if the oil contained acid, there will be a green spot on the metal. Blue litmus paper dipped in acid-free oil stays blue, but becomes red if the oil contains acid. A good oil must be greasy and sticky: to find which of several oils is best in this respect, place a few drops of the different oils on a smooth, slightly inclined metal or glass sheet; the drop of the stickiest oil will travel furthest in a given time. The article describes also methods for testing oils for viscosity and flash-point, but this part is omitted because the tests described require apparatus not usually available in the engine room, and unless done with proper care and appliances present in some cases considerable danger.

Processes of Treating Wood with Chemicals in order to Produce Materials Stable with Respect to Various Influences (*Die Verfahren zur Behandlung des Holzes mit Chemikalien zum Zwecke gegen die verschiedensten Einflusse beständige Produkte zu erzeugen*, S. Halen. *Kunststoffe*, vol. 2, nos. 22 to 24, pp. 424, 449, 461, November 15, December 1 and 15, 1912. 15 pp. *d*). List of patents, foreign and American, with brief statement as to the process patented, on the *treatment of wood* by various preservatives. Several hundred patents are quoted.

Safety of "Highly Strong" Winding Ropes (*Sicherheit hochfester Förderseile*, D. F. Baumann. *Glückauf*, vol. 49, no. 4, p. 117, January 25, 1913, 3½ pp. *e*). The article is written mainly on the basis of the data obtained in the experiments of Speer with a view to determine the principles to be used in installation of *winding ropes of very strong materials*. The author concludes that the number of safe bendings of a rope increases with the increase of the breaking strength of its wires (a fear was expressed that ropes made of very strong material in fracture would prove weak in bending); rapidly increases with the increase in the radius of curvature; and slowly decreases with the increase of load. It is therefore advisable to select ropes of high strength for great depths and large loads; it is not absolutely necessary to use larger pulleys for very strong ropes.

Thermodynamics

Specific Heats and Specific Volumes of Steam for Pressures up to 20 Atmospheres and Temperatures up to 550 deg. cent. (*Die spezifische Wärme und das spezifische Volumen des Wasserdampfes für Drücke bis* 20 *at und Temperaturen bis* 550° *C.*, Max Jakob. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 49, p. 1980, December 7, 1912. 8 pp., 3 figs. *etA*). The author starts with Clausius thermodynamic relation determining the relation between c_p and v, and shows that the determination by its means of c_p as a function of v is extremely difficult, since it depends on the curvature of the isobars in the vT diagram, which is, however, very slight and can scarcely be determined exactly; as a result, equations which have v correct to tenths of 1 per cent, may lead to

values of c_p being several per cent wrong. On the other hand, v may be determined from c_p fairly correctly. From the Clausius relation, by double integration in T, is obtained:

$$v = \Phi(p) + T\Psi(p) - \frac{1}{A}\int\int\frac{1}{T}\frac{\partial c_p}{\partial p}dT_2 \ldots\ldots\ldots\ldots [1]$$

If the legitimate assumption is made that the steam is in the state of an ideal gas when $\frac{\partial c_p}{\partial p} = O$, and as the initial point of integration is selected the temperature T_o corresponding to $\frac{\partial c_p}{\partial p} = O$, then:

$$v = \frac{BT}{p} - R = \frac{BT}{p} - \frac{1}{A}\int_{T_o}^{T}\int_{T_o}^{T}\frac{1}{T}\frac{\partial c_p}{\partial p}dT^2 \ldots\ldots\ldots\ldots [2]$$

This requires only double integration of a simple differential quotient, and integration of imperfectly known functions not only does not introduce material errors, but often eliminates some imperfections of the function. If therefore $\frac{\partial c_p}{\partial p}$ contained errors as high as 10, or even 20 per cent, which with our present knowledge is possible even in the case of the best determined values of c_p, that would materially affect only the member R, while the value of v would be hardly out more than a few tenths of 1 per cent. When therefore H. N. Davis called the reconciliation of the accepted volume and specific heat measurements in the superheated region "the most important of the outstanding problems in the field," he had in view the passage from v to c_p, and not vice versa, which is the object of the present article. To do this the author uses a graphical method stating that any formula that he might derive would be so complicated and involve such integrations as to be inapplicable in practice, and would have to be simplified to make them applicable, while graphical methods require no such adaptations; further, after the chart is made, they may be used with as much convenience as formulae.

For these tests values of c_p for pressures up to 20 atmospheres, and temperatures up to 550 deg. cent. were used from the experiments of Knoblauch-Jakob-Hilde-Mollier, as well as the data of the experiments of H. N. Davis. In Fig. 9 A the isobars are plotted on a c_pt diagram in steps of 2 atmospheres for pressures from 0 to 20 atmospheres, the isobar for 1 atmosphere pressure being plotted as a dotted line. Each isobar extends from the saturation limit to 550 deg. cent., the line on the left representing the saturation curve (the original article has tables containing the values from which this and the other curves were plotted). The isobars for 2, 4, 6, and 8 atmospheres according to the Knoblauch-Jakob-Mollier experiments are here plotted anew, and differ but little from those published by Knoblauch-Hilde-Mollier, the difference in c_p only in one case exceeding 0.5 per cent (at the saturation point of the 2 atmosphere curve). The curve for $c_{po} = \phi(T)$ was determined both from the Davis equation and from the values of c_p for 2 to 8 atmospheres; the value for 1 atmosphere was found by interpolation.

Tests are now being made at the Laboratory for Technical Physics of the

Munich Technical High School to determine the isobars for pressures from 10 to 20 atmospheres (those of Knoblauch and Jakob were found by interpolation). The isobars in Fig. 9A were derived from the curve for c_{po} on one hand and the Davis

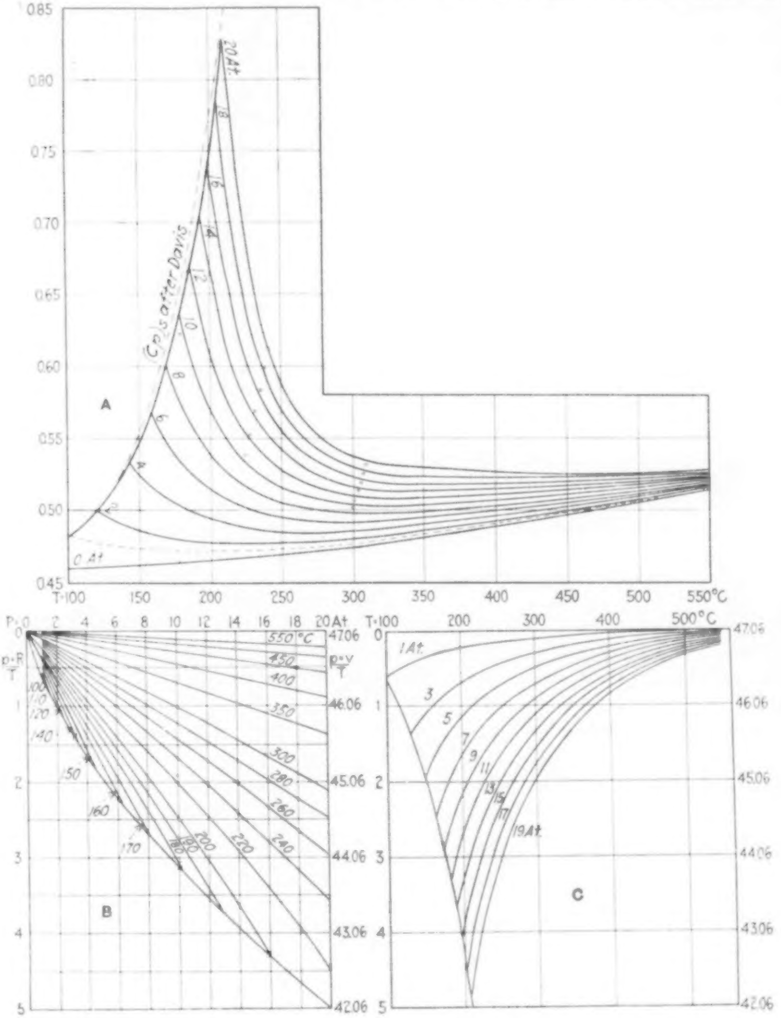


Fig. 9 Jakob Charts for the Determination of Specific Heats and Specific Volumes of Steam

values of $\frac{c_p}{c_{po}}$ at pressures of 10, 12, 14, 16, 18, and 20 atmospheres; the precise values so derived have been plotted as little circles. For the saturation curve the author proposes the equation

$$(c_p)_s = 0.455 + 2.10^{-20}\frac{T_s^{\,8}}{T_k - T_s} \qquad [3]$$

instead of the Knoblauch and Jakob which failed for pressures below 2 atmospheres. The new equation gives exact values for saturation points at 2, 4, 6 and 8 atmospheres, and provides further that $(c_p)_s$ becomes infinitely large at the critical temperature $T_s = T_k$, as required by thermodynamics. It holds good down to very small pressures, as the author shows by examples. It is of interest to note that the new Jakob equation coincides very well with the Davis values of $(c_p)_s$: the variation between the Davis saturation curve in Fig. 9A and the Jakob curve is less than that between the Davis curve and the points from which it was derived.

The author calculates, on the basis of the Davis equation for r, the values for the heat contents i, and thereby proves that his c_p system satisfies the condition imposed by Knoblauch-Hilde-Mollier, viz., that at constant temperature to the increase of c_p with the pressure corresponds a simultaneous decrease of the heat contents. The decrease of i with increase of pressure is irregular, owing to the decreasing exactness of the values of i, and an extension of the isobars to correspond with higher temperature would give a point of intersection at 920 deg. cent., where i would be equal for all pressures.

The author explains further, though he does not show it, how from Fig. 9A he obtained graphically the values for R and v in equation [2]. From the system of isobars of Fig. —A was derived a system of $\left(\frac{\partial c_p}{\partial p}\right)_p = g(t)$ isobars by dividing the difference $(\Delta c_p)_T$ between each two contiguous isobars by their pressure difference $\Delta p = 20{,}000$ kg. per qm.; from this the second derived system of $\left(\frac{1}{AT}\frac{\partial c_p}{\partial p}\right)\Big| = h(t)$ was obtained by dividing the first by $\frac{1}{AT}$. Each of the curves of these latter isobars was next integrated by means of a planimeter from the common point of intersection $t_0 = 920$ deg. cent., or $T_0 = 1200$ deg. abs., to different temperatures between T_0 and the saturation temperature T_s, which gave a new series of isobar values $\int_{T_0}^{T} \frac{1}{AT}\frac{\partial c_p}{\partial p}\, dT = j(t)$; after these values had been integrated in a similar manner by means of a planimeter, a series of values for R were obtained (the author gives them in a table), from which the values of v had been derived by substituting for B the value of the gas constant for steam, or 47.06 (a table of v values is also given). The values of $\frac{pR}{T}$ with R derived as described above are plotted in Fig. 9B as isotherms, and in Fig. 10C as isobars.

General Form of an Equation of State. Linde and others have tried to establish an equation of the form

$$\frac{pv}{T} = B - F(p)G(T) \qquad [4]$$

In the author's estimation Fig. 9B and C take the place of such an equation, where Fig. 10B shows in addition that $F(p)$ is developed as a function of increasing exponents of p, and $G(T)$ of those of $\frac{1}{T}$. The complete solution of this equation by means of these curves, though possible with approximate correctness, would be of value only if the double differentiation in v and T of the Clausius relation would give values of c_p agreeing with those accepted at the beginning of

TABLE 1 SPECIFIC VOLUMES ACCORDING TO JAKOB (v_J) AND LINDE (v_L)

P in atmospheres, deg.		1	3	5	7	9	11	13	15	17	19
$t=t_s$	v_J	1.7281	0.6182	0.3826	0.2785	0.2195	0.1813	0.1546	0.1346	0.1193	0.1071
	v_L	1.7260	0.6173	0.3820	0.2782	0.2190	0.1810	0.1543	0.1344	0.1190	0.1068
$t=130$	v_J	1.8789	......	......	......	......	......	......	......	......	......
	v_L	1.8783	......	......	......	......	......	......	......	......	......
$t=160$	v_J	2.0237	0.6646	0.3923	......	......	......	......	......	......	......
	v_L	2.0245	0.6643	0.3918	......	......	......	......	......	......	......
$t=190$	v_J	2.1674	0.7146	0.4239	0.2992	0.2296	0.1852	......	......	......	......
	v_L	2.1695	0.7152	0.4240	0.2990	0.2293	0.1848	......	......	......	......
$t=220$	v_J	2.3107	0.7639	0.4544	0.3217	0.2479	0.2009	0.1683	0.1443	0.1259	0.1113
	v_L	2.3137	0.7653	0.4550	0.3223	0.2483	0.2011	0.1683	0.1441	0.1256	0.1108
$t=250$	v_J	2.4535	0.8127	0.4844	0.3437	0.2655	0.2157	0.1812	0.1558	0.1364	0.1210
	v_L	2.4571	0.8147	0.4860	0.3450	0.2665	0.2165	0.1818	0.1563	0.1368	0.1213
$t=300$	v_J	2.6909	0.8932	0.5337	0.3795	0.2939	0.2993	0.2016	0.1739	0.1527	0.1359
	v_L	2.6954	0.8960	0.5361	0.3817	0.2959	0.2412	0.2034	0.1755	0.1543	0.1374

the investigation, which is not the case. It appears that there is some error common to all the equations of state of the form of [4], and the author thinks that the trouble is not with his values of R and v, but with the equation itself which, to be true, must be of a more complicated form like

$$\frac{pv}{T} = B - H(p, T) \qquad [5]$$

The values marked v_L in Table are those (Table 9 in the original) determined from the experiments of Knoblauch, Linde and Klebe by means of the Linde equation within the range of the greatest applicability of this equation. The part within the heavy black line lies within the proper range of the determinations of Knoblauch-Linde-Mollier: there the difference between v_J and v_L does not exceed 0.25 per cent, while the error in v_L itself may be as high as 0.2 per cent. The agreement between the two sets of values is therefore a close one. For higher pressures in the range of superheat the difference is greater, due mainly to the fact that according to the Linde equation $R=0$ at 405 deg. cent., while according to Jakob it does not reach the 0 value until 920. deg. cent. Where the Jakob values differ in the domain of saturation and higher pressures from those of Linde, they at the same time approach those calculated by Schüle from the determinations of Ramsay and Young, though the difference with respect even to these last values at 19 atmospheres is quite considerable (1.4 per cent); this is due to the fact that at that pressure R is nearly 10 per cent of the value of v, and an error in its determination, which may in itself be as high as 10 per cent, affects the value of v quite appreciably.

Heat Transmission from Flowing Air to Pipe Walls (*Der Warmeubergang von strömender Luft an Rohrwandungen*, Grober. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 130, p. 1, 24 pp., 22 pp. *eA*). For preliminary notice of this investigation see *The Journal*, June 1912, p. 972). The author shows that the heat transmission is an exponential function of the velocity of flow and that the exponent of the latter in this case is 0.81. The relation between heat transmission and temperature of air and pipe walls is also expressed by exponential functions, but the exponents themselves vary with temperature. The author confirms the Nusselt statement as to the relation between the heat transmission and length of pipe (see *The Journal*, June 1912, p. 972), and finally establishes the following experimental formula:

$$\alpha = \left(3.81 + \frac{82.8}{t_L} - \frac{(273 - t_w)^2}{29{,}100}\right) \frac{(w\rho)^m}{D^{1-m}}$$

where α is the coefficient of heat transmission in calories per meter square per deg. cent. per hour; t_L temperature of the air in deg. cent.; t_w temperature of the pipe wall in deg. cent.; w velocity of the flow of air in meters per sec.; ρ specific weight of air in kg. per sq. m; D diameter of the pipe in m; m a constant for the pipe under test $=0.81$. The formula was confirmed experimentally for a pipe of $D=0.062$ m (say 2.5 in.) and for ranges of temperature: $t_w = 75$ to 250 deg. cent. (122 to 482 deg. fahr.) and $t_L = 100$ to 325 deg. cent. (212 to 617 deg. fahr.). See also the equation for α in the article quoted above.

Heating Process with Gases and Catalytically Acting Bodies (*Heizverfahren mit Gasen und katalytisch wirkenden Korpern*, Ludwig Schmidt. *Zeits. für Beleuchtungswesen*, vol. 18, no. 35, p. 427, December 20, 1912. ½ p., 3 figs. *d*). Description of a new process of combustion of gases patented in Germany in which

a catalyser is used to maintain the constant combustion of the gas and air mixture. Full description of this process is not here given because neither the original article nor the patent specification mention what material is used as a catalyser.

Miscellanea

Exchange of Trained Apprentices (*Austausch ausgelehnter Lehrlinge*, O. Stolzenberg. *Werkstattstechnik*, vol. 7, no. 2, p. 49, January 15, 1913. *g*). The German works have found that often a man who has gone through an apprenticeship course in a concern which maintains such a course, sometimes at a great expense to itself, goes to another concern to work afterwards. In itself such a thing is natural, because the young man wants to see the world, sometimes to escape for a time from the home atmosphere (where the plant of his apprenticeship is near his home, as is often the case); in traveling he grows morally and mentally, and learns new processes and methods of work, so that when he comes back to the plant where he took the apprenticeship he is really a more useful man than he would have been had he stayed there all the time. The problem is therefore to make sure that he does come back, and to do this the Maschinenfabrik Augsburg-Nürenberg and the Ludw. Loewe & Co. A-G. have entered into an agreement according to which the apprentice who after the completion of his period of training expresses the desire to travel, is directed to the other concern; he is, however, requested to write to his old firm every three months telling them how he is getting on; the connection therefore remains, and the man knows that he is always welcome to come back.

ARTICLES UPON GAS POWER

(Prepared by the Gas Power Literature Committee)[1]

DIESEL MARINE ENGINES, THE STARTING OF. *The Engineer* (London), January 10, 1913. 2 pp., 8 figs. *cdpA*.

Various starting gears.

LIGHTSHIP, A MOTOR PROPELLED. *The Engineer* (London), January 3, 1913. *dpB*. 1 p., 3 figs.

Describes the lightship Elbe with 220 h.p., brake, reversible four-cycle, two-cycle Diesel engine.

DIE KUHLUNG DER VERBRENNUNGSKRAFTMACHINEN, Hans Windhoff. *Elektrotechnik und Maschinenbau*, October 20, 1913. 1/8 p.

Review of article on the cooling of internal-combustion engines in Der praktische Maschinen-Konstrukteur, September 12, 1912.

MARINE INTERNAL COMBUSTION ENGINES. *The Engineer* (London), January 3, 1913. 1½ pp. *cdpA*.

The year's work.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

REPORTS OF MEETINGS

CHICAGO MEETING, FEBRUARY 6

A meeting of the members of the Society in Chicago was held on February 6 at the rooms of the Western Society of Engineers, with about 65 members and guests in attendance.

The subject of the evening was Internal-Combustion Engines, E. T. Adams, chief engineer of the Rumely Company, Laporte, Indiana, being the first speaker. Mr. Adams spoke of his own experiences in this field, and discussed the possibilities of building large gas engine units, stating that in his opinion it would be practical to build a two-cylinder four-cycle engine of 5000-kw. capacity and that the cost per unit of such an engine would be as much cheaper when compared with the smaller sizes, as the present turbo-generators are cheaper than the small units. He discussed also the different fuels available for gas engine operation and showed that the supply of gasolene and other products of petroleum is very limited. He mentioned the difficulties of using by-product gas and stated that he thought the gas producer using pulverized coal offered many attractions which would no doubt lead to its successful production in time.

The last part of Mr. Adams' talk was devoted particularly to small engines such as he is working on at present; he brought out the fact that the power requirements of the farmer are very much larger than have heretofore been appreciated. In discussing the fuel available for the farmer's engine, he again spoke of the limited supply of gasolene and kerosene; he expects that the fuel of the future can be made entirely from the products of the farm, and that alcohol made from potatoes and other products, will be one of the main fuels. Government regulation is holding back the development along this line at present. Mr. Adams stated that practically all the forms of internal-combustion engine, including the Diesel, have the same records for economy.

Prof. Chas. R. Richards of the University of Illinois discussed the field of internal-combustion engines in general, and made particular reference to some recent experiments of Professor Parr, of the University of Illinois, on the low temperature distillation of bituminous coal driving off a heavy gas rich in by-products and leaving a "semi-coke," which he felt could be used in gas producers for power purposes. Professor Richards also discussed the fuel situation, agreeing with Mr. Adams that some fuel other than gasolene and kerosene would have to be developed in the near future.

J. C. Miller, consulting engineer, Chicago, described some of his experiences during the early days of gas engines and gas producers. He

brought out the fact that many installations had failed because they had not been properly designed for the fuel, and that they had not been carefully operated.

Nisbet Latta, formerly with the Wisconsin Engine Company, spoke of his experience with gas producer gas engine installations, and described the difficulties encountered and prophesied, as did Mr. Adams, that a gas producer operated with pulverized coal would some day be perfected.

W. H. Hazard, and the following members of the Society, H. H. Wait, John M. Sweeney, and S. S. Howell, also took part in the discussion.

ST. LOUIS MEETING, FEBRUARY 5

At a meeting of the Associated Engineering Societies of St. Louis on February 5, held under the auspices of members of The American Society of Mechanical Engineers in that city, a paper on The Lubricating Value of Cup Greases was presented by the author, Prof. A. L. Westcott of the Missouri State University, Columbia, Mo., and illustrated by lantern slides. Professor Westcott described a number of tests of cup greases under a variety of conditions as to bearing pressure, temperature and method of application of the grease for coefficient of friction and general suitability as a lubricant. The paper was discussed by E. L. Ohle, John Hunter, G. R. Wadleigh, F. E. Bausch, and Mr. Schuyler. The meeting was largely attended.

A more complete account of the meeting will appear in a later issue of The Journal.

PHILADELPHIA MEETING, FEBRUARY 8

A meeting of the members of the Society in Philadelphia and vicinity was held in the Engineers Club of Philadelphia on February 8, 1913, A. C. Jackson, chairman of the local committee, presiding. About 175 members and guests were in attendance.

After the transaction of business, the paper of the evening, Overhead Expense Distribution, was presented by the author, Royal R. Keely, in which he discussed the various methods employed in computing this important item and their relative merits. It was discussed by Harrington Emerson, Henry Hess, Walter M. Kidder, J. F. Wickersham, Carl G. Barth, F. G. Coburn, F. C. Andrews, and A. C. Jackson.

A more extended account of the meeting will appear in a later issue.

NEW YORK MEETING, FEBRUARY 11

At a meeting of the New York membership in the Engineering Societies Building, on February 11, Wm. T. Donnelly presented a paper on Port Facilities for Ships in the United States, which was illustrated by lantern slides, in which he described the present situation in various ports and outlined the improvements which he considered necessary to make the facilities adequate. Mr. Donnelly's wide experience, as a representative of the State of New York on the Atlantic Deeper Waterways Commission and on the Inland Waterways Commission, as consulting engineer for the State of Connecticut in relation to their harbor matters, and also as consulting engineer for the work being done at Prince Rupert by the Canadian Pacific Railroad, and with many other similar activities, has given

him the opportunity to study the question at first-hand, and supplied an added interest to the paper. The paper was discussed by H. McL. Harding, Harry Sawyer, Elias Cahn, George A. Orrok, F. L. Du Bosque and W. C. Brinton, and H. R. Cobleigh presided over the meeting.

A more extended account of the meeting will be published in a later issue of The Journal.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a regular meeting of the Armour Institute of Technology Student Branch on February 5, W. H. Green presented a paper on the Wiley Fuel Economy Gage, which indicates and records the relative efficiency of the boiler. Discussion followed in which many participated.

CASE SCHOOL OF APPLIED SCIENCE

At the meeting of the Council on February 14, the establishment of a new student branch at the Case School of Applied Science was authorized.

POLYTECHNIC INSTITUTE OF BROOKLYN

At a meeting of the Polytechnic Institute Student Branch on February 1, T. W. Reed of the engineering department of the General Electric Company gave a lecture on Steam Turbine Principles, Design and Operation, which was followed by discussion. On February 15 members of the branch made an excursion to the power plant of the Long Island Railroad.

PURDUE UNIVERSITY

On January 28, the meeting of the Purdue Student Section was addressed by Dean Benjamin on the Development of the Mechanical Arts, in which he pointed out that the present advanced stage was not achieved in a day but was gradually developed from the crude implements of our forefathers.

The following officers were elected for the semester: L. L. Savage, president; A. D. Meals, vice-president; S. A. Peck, treasurer; G. F. Lynde, recording secretary; A. S. Romig, corresponding secretary.

On February 11, H. S. Dickerson, Mem. Am. Soc. M. E., gave an interesting talk on the Apprenticeship Course for the College Graduate.

UNIVERSITY OF KENTUCKY

A meeting of the University of Kentucky Student Branch was held on February 7, when an illustrated lecture of the Steam Valve as a Metallurgical Problem was delivered by George K. Elliott, chief chemist and metallurgist of the Lunkenheimer Company of Cincinnati. Mr. Elliott drew attention to the latest practice in the mixture of bronze and brass alloys used in the manufacture of steam valves.

UNIVERSITY OF MISSOURI

The following officers were elected at the meeting of the University of

Missouri Student Branch on January 20: W. P. Jesse, president; R. Runge, secretary and treasurer; J. H. Pound, corresponding secretary. At the conclusion of business, Prof. L. M. Defoe gave an instructive talk on City Administration, which was followed by a general discussion.

UNIVERSITY OF NEBRASKA

The University of Nebraska Student Section have taken up with the faculty the matter of having an "engineers' night" when the laboratories will be open and running for the inspection of visitors, and a committee has been appointed to investigate its feasibility.

UNIVERSITY OF WISCONSIN

The following officers were elected at the January 23 meeting of the University of Wisconsin Student Branch: W. K. Fitch, president; G. B. Welser, vice-president; E. S. Gillette, secretary; W. H. Schleck, treasurer.

NECROLOGY

JOSEPH HARLAN FREEMAN

Joseph Harlan Freeman, consulting engineer and mechanical expert, died in Brooklyn on January 27, 1913, at the age of 44. As a boy he was obliged through the death of his father to leave school and become a printers' apprentice with the Tradesman Company, Grand Rapids, Mich. Dissatisfied with his lack of education, he applied for admission in the Michigan Agricultural College at the age of nineteen, and was graduated with the degree of B.S. in 1890. Upon completion of his course he became a designer and foreman with the Buss Machine Works of Grand Rapids, and designed several important new machines.

From 1891 to 1898 he served as an examiner in the Patent Office in Washington, studying law in the evenings at the Georgetown University. His early experience with printing machinery and his knowledge of the art caused him to be placed in that division of his department, and his good work soon attracted the attention of a firm of patent attorneys in New York, who engaged him to take charge of this phase of their own practice.

In 1903 he established an independent office as a consulting engineer and patent expert, which he conducted up to the time of his death.

CHARLES N. TRUMP

Charles N. Trump was born at Newport, Bucks County, Pa., on May 30, 1829, of Quaker parentage, and received his education in a private school of Alexandria, Va., his father having engaged in the lumbering business in Baltimore. In spite of opposition by his family, who wished him to enter one of the professions, which did not then include mechanical engineering, he apprenticed himself in one of the machine shops of Baltimore.

Naturally a student, Mr. Trump absorbed all the engineering information available, and becoming interested in gas engineering, opened an office in Philadelphia for the erection of gas works, especially to develop a system of manufacturing gas from resin. He

erected several works in different parts of the country, but during the Civil War was obliged to abandon his business and to take up insurance. In 1865 he was engaged by Russell, Birdsall & Ward, Port Chester, N. Y., to take charge of a section of the works.

In 1870 he and his brother opened a machine business in the same town, under the name of Trump Brothers Machine Company, and developed a line of manufacture of foot-power scroll saws, special chucks, and other light machines. Two years later they moved the business to Wilmington, Del., considerably enlarging it and taking up the manufacture of knitting machinery. Mr. Trump retained for many years the presidency of the company, and retired only a short time before his death on December 30, at the age of 83.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society and good men not members. Information will be sent upon application.

POSITIONS AVAILABLE

032 Assistant editor on the staff of a leading engineering journal. Must be a graduate in mechanical engineering with first-rate record as student and have had one to four years experience in engineering work. Ability to write clearly and concisely and possession of sound engineering judgment are essential. State age and give full record of education and past work with references; also salary expected. Apply through the Society.

033 Patent office draftsman for concern in Massachusetts. Must be competent to make up patent office drawings and write description either from the machines or assembly drawings.

034 Draftsman from \$80 to \$100 a month for manufacturers of special steel castings and machinery. Location, New Jersey.

035 Draftsman; technical education preferred. Experienced in design and layout of ore crushing and conveying machinery. Salary \$125 to \$150 a month.

036 Draftsman, experienced in locating and laying out pumping plants, pipe lines, etc. Technical education preferred. Salary \$125 to \$150 a month.

307 Man to take charge of car repairs; one with experience in this line preferred and with technical education. Salary \$75 to \$100 a month.

038 Large manufacturing concern wants several mechanical engineers with executive ability and experience in power house work and methods of shop practice. Location, Pennsylvania.

039 High-grade well trained energetic engineer to act as chief draftsman and designer in a new enterprise of experimental character. Location, Massachusetts. Apply through the Society.

040 Works manager for machinery manufacturing plant in England, employing 600 men in the production of pumping machinery of every type and size. Must be experienced in all branches of modern machine shop and foundry practice, and possess such engineering knowledge as successfully to meet local competition. Salary \$5000 per year. Confidential, apply through the Society.

041 Manager to have charge of department manufacturing gasolene and

oil engines, employing about 1000 men. Must have experience in manufacturing in accordance with modern methods and ability to handle men and modernize systems employed in shop for economical and efficient production. Excellent position for right man. Location, Middle West.

042 Several first-class draftsmen on design of open-hearth steel, blast furnaces, rolling mill or allied work. Men capable of acting as leaders. New York concern.

043 First-class power house engineer, one familiar with both steam and electrical plants. Location, New York.

044 New York concern desires to arrange working agreement with engineers with experience in special fields of activity. Want a man exceptionally strong in designing improved machinery or perfecting machines now in use who will act as consulting engineer in such matter, *especially at this time.*

045 Young technical graduate preferred as draftsman on power-house layouts, piping, etc. Salary, $18 to $20 per week. Position will give good experience in above line and probably lead to advancement.

046 Experienced man wanted on scientific rate setting, time study and detailed analysis for concern manufacturing gas and gasolene engines and now operating shop under the bonus system. Location, Ohio.

047 Assistant engineering editor for company in Middle West. To the right man who has had experience in the preparation of copy for trade publications position would pay up to $175 a month. Applicant should be engineering graduate and if possible with experience in foundry and machine shop work; training along iron and steel lines desirable.

048 Draftsmen, preferably with experience in mechanical lines, particularly power plant machinery and piping, boilers, boiler settings, etc. Location, Connecticut.

MEN AVAILABLE

38 Junior member, age 30, technical graduate, with seven years' experience in the design, construction, operation and maintenance of power plants and substations and in testing electrical machinery; desires position of responsibility with hydroelectric company or with contractors doing power plant or hydroelectric work. Best references. $150-$200 per month. At present employed.

39 Man familiar with presses, dies and other tools for manufacturing sheet-metal goods, has given considerable attention to efficient manufacturing and the design of special machinery and tools.

40 Factory man and engineer, now head of engineering department of large company, desires position as works manager, preferably with new company.

41 Junior member, A. B. Yale, M. E. Columbia, would like to associate with engineer or firm making specialty of design and construction of industrial plants. Experience in this line as superintendent of construction, assistant to works manager, etc.

42 Junior member, technical graduate, age 30, experienced in crane and hoisting machinery design, desires position with progressive firm as designing engineer or chief draftsman. Can show results in improved efficiency of drafting room.

43 Technical graduate, age 37, practical mechanic with 10 years experience in executive capacity, mill engineering, power generation, transmission, etc.; desires position with large progressive concern in New England as factory engineer or works manager.

44 Mechanical and architectural engineer, age 32, desires position in New York City, preferably with manufacturing concern or with firm of architects. Familiar with industrial and power plant engineering. Assoc. Mem.Am.Soc.C.E. Licensed architect State of Illinois.

45 Member, Stevens Inst. Tech. graduate, 16 years engineering and executive experience, desires position as purchasing agent, sales supervising or production engineer, or office manager with some growing concern.

46 Member desires position as works manager; technical graduate, 15 years manufacturing experience; successfully carried entire managerial responsibility. Executive ability, thoroughly able to develop factory organization in most modern methods of control of production. Familiar with high-grade interchangeable and precision work in quantity. Highest credentials.

47 General superintendent with thorough practical experience in organizing, directing production, tactful management, plant layouts, interchangeable manufacture, machine and tool design, and practical application of modern efficiency methods in electrical, machine and tool lines; desires change to better position with opportunity of further advancement.

48 Member, age 34, technical graduate, 11 years experience machine shop, designing, manufacturing, erecting, and selling hydraulic turbines, governors, penstocks, etc. Experienced in making examinations, efficiency tests and reports of electric power plants, well grounded in electrical and steam engineering. At present employed but desires change. Prefers position with consulting engineer or public utilities corporation.

49 Graduate mechanical engineer, who has been following editorial work, wishes position in similar line or in connection with technical advertising. Would be interested to hear of any selling positions with good prospects for the future. Best of references as to ability and character.

50 Sales manager, exceptional experience selling boilers, engines and complete power plants as well as their design, construction and installation. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years successful selling in territory east of and including Pittsburgh and Buffalo. Member with both practical and technical training.

51 Manager or engineer capable of taking charge of sales department, advertising and correspondence or shop.

52 Thoroughly competent refrigerating engineer open for an engagement. Familiar with absorption and compression machines, refrigerating and ice making in all details. Designing, construction and operation. Valuable experience.

53 Junior, graduate mechanical engineer, 10 years experience as superintendent construction. Master mechanic in large factory; past three years with beet sugar company in charge of designing, constructing and operating numerous pumping plants, irrigation systems, pipe and power lines, accustomed to figuring cost and purchasing materials. Executive ability and excellent references; desires to make change about May 1.

54 Member, age 39, long practical experience including a year and a half in Europe, now associate professor of mechanical engineering, desires similar position in a growing university.

55 Junior member, age 28, twelve years experience on open-hearth furnace and fuel gas producer plants, designer and resident engineer of construction, desires a position of responsibility with a chance of advancement.

56 Associate, M. I. T. graduate, 25 years experience in miscellaneous engineering, designing and manufacturing work, some office and selling experience; desires position in Chicago.

57 Member with successful experience in high-grade interchangeable manufacture, desires position as superintendent or assistant in manufacturing plant. Especially familiar with steam turbine work. Available April 1.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

ERROR IN FEBRUARY ISSUE

Through an error in The Journal for February, the gift of the Una-Flow Steam Engine by J. Stumpf, was credited to Edward H. Trump instead of Edward N. Trump.

Air Brake Association. Proc. annual conventions 16–17, 19. 1909, 1910, 1912. *1909, 1910, 1912.*

———Standard Form of Questions and Answers on the Westinghouse Air Brake for Beginners and Advanced Students. 1913. *Boston, 1913.*

American Gas Furnace Company. Automatic Heat Controller. Invented by Geo. F. Machlet. *New York.* Gift of company.

American Railway Association. Proc. Chicago session, November 20, 1912. Gift of association.

American Water Works Association. Proc. 32d annual convention, 1912. *Troy, 1912.* Gift of association.

Atlantic Deeper Waterways Association. Report of Proc. 5th annual convention, September 4–6, 1912. *Philadelphia, 1912.* Gift of association.

Ballon-und Flugmotoren, A. Haenig. *Rostock i. M., 1910.*

Boston Transit Commission. 18th annual report, 1912. *Boston, 1912.* Gift of commission.

Car Builders' Dictionary. ed. 7, 1912. *New York, 1912.*

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